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ENGINEERING:

An Illustrated Weekly Journal.

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Tenders on prescribed forms, properly endorsed, must be delivered to:—
R. LIDDELOW, Secretary, Electricity Commissioners, 375, Bourke Street West, Melbourne, Victoria, Australia, not later than Noon on 24th February, 1921.
(Signed) PETER McBRIDE, Agent-General for Victoria. K 910

MANCHESTER CORPORATION TRAMWAYS.

The Tramways Committee of the Manchester Corporation are prepared to receive

Tenders for the Supply of the

following, viz.:—
(A) TURNING AND BORING LATHE.
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Specifications and Forms of Tender may be obtained on application to Mr. J. M. McElroy, General Manager, Corporation Tramways, 55, Piccadilly, Manchester.

Tenders are to be addressed to the Chairman of the Tramways Committee, 55, Piccadilly, Manchester, and must be received not later than Ten a.m. on Tuesday, the 14th December, 1920.

The Committee do not bind themselves to accept the lowest or any Tender.

THOMAS HUDSON, Town Clerk.

Town Hall, Manchester, 27th November, 1920. K 944

THE BURMA RAILWAYS COMPANY, LIMITED.

The Board of Directors of the Burma Railways Company, Limited, are prepared to receive

Tenders for the Supply of:

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For each copy of the Specification a fee of 20/- will be charged which fee is not returnable. Tenders enclosed in sealed envelope addressed to the "Chairman and Directors," and endorsed "Tender for Helical Springs" must be delivered at the Company's Offices not later than 12 noon on Monday, 13th December, 1920. The Directors do not bind themselves to accept any or the lowest Tender, and reserve the right to divide the order.

The Springs are urgently required in Burma.

By order of the Board, W. HOMN, Managing Director.

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The selected candidate will be required to obtain a medical certificate of fitness for work from a medical practitioner selected by the Board.

D. E. WACHA, Hon. Secretary of the Board of Trustees. Victoria Jubilee Technical Institute, (Central Technological Institute) Byculla, Bombay, India. K 967

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Applicants must have served in some branch of His Majesty's Forces during the late War unless satisfactory reasons for not having done so can be furnished. K 969

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Two Superintendents

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Railway Construction REQUIRED for the undermentioned vacancies by the Government of the Gold Coast, for two tours each of 12 months' service with possible extension. First class passages. Free quarters or a field allowance of £7 10s. a month in lieu thereof. Liberal leave in England on full salary.

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Appointment: District Engineers.
Salary: £800 a year.
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Appointment: Assistant Engineers.
Salary: £600 a year.
Qualifications: Good charge experience on railway construction. Previous experience on railway construction.

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Civil Engineers Required

by the Government of Nigeria, for the Railway Department (Eastern Railway Surveys), for two tours each of twelve months service, with possible extension as Junior Assistant Engineers, with salary of £800 a year, rising by annual increments of £30. A commuted allowance of £12 a month in lieu of quarters, etc., is payable only whilst actually in Nigeria.

Camp equipment and first-class passages provided. Liberal leave in England on full salary after each tour.

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ENGINEER.

Applications are Invited for

the POSITION of ENGINEER to the Ouse Drainage Board. The Salary offered is £800 per annum together with an allowance of £200 per annum for travelling expenses. Office accommodation and staff will be found by the Board or an allowance made in lieu thereof.

Canvassing will be a disqualification.

Particulars of the duties and forms of application will be sent by me on receipt of a stamped addressed foolscap envelope.

Applications accompanied by three recent testimonials must be received by me not later than 15th December, 1920.

ASHLEY TABRUM, Acting Clerk.

County Hall, Cambridge. 30th November, 1920. L 31

SUDAN GOVERNMENT.

SUDAN GOVERNMENT RAILWAYS AND STEAMERS DEPARTMENT requires the

Services of a District Engi-

neer, age 25–30 years.

Qualifications: Civil Engineer with permanent way experience, A.M.I.C.E., or students of same, public school education. Salary £480 plus bonus of £120, which is subject to alteration by Government (£1 = £1 0s. 6d. sterling, approx.). No income tax is charged or contemplated in the Sudan. Permanent, if retained in the service after expiration of usual 12 months' contract, which may be extended by 6 months at option of Government. Apply by letter enclosing copies of testimonials to SIR A. L. WEBB, K.C.M.G., Queen Anne's Chambers, Broadway, Westminster, S.W. 1. Applications to be marked "District Engineer, S.G.R." L 1

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Dredger in the Sudan. The man required should if possible have had practical experience of Dredger work or the handling of large steam excavators. Salary £34 per month, plus 40 per cent. Sudan Allowance, plus 20 per cent. War Gratuity, the latter being the scale at present in force and payable as long as sanctioned by Government.

Travelling Allowance extra according to regulations in force.

£1 = £1 0s. 6d. sterling. (No income tax is charged in the Sudan.)

Unmarried man preferred.

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Applications in writing to be addressed to SIR A. L. WEBB, K.C.M.G., Queen Anne's Chambers, Broadway, Westminster, S.W. 1.

Envelopes to be marked "Dredger Engineer." L 31

MAGNETO TESTING AND THE CHOICE OF A SPARK GAP.

By A. P. YOUNG, M.I.E.E., M.I.A.E.

THE primary function of a magneto, and of all other forms of ignition apparatus, is to produce a rapid succession of sparks which are timed to occur inside the engine cylinders in proper sequence, and in synchronism with the movement of the pistons. It is natural, therefore, that the usual workshop methods of testing a magneto resolve themselves into a determination of the capability of the machine to produce sparks under diverse conditions. We are not concerned at the moment with the many ingenious methods that have been devised by scientific investigators in their attempt to elucidate the elusive characteristics of a magneto spark, such as by measuring its heat energy and "capacity" component, or by determining how the machine behaves when excessive leakage is made to occur in the high-tension circuit. Tests of this kind necessitate the use of a considerable amount of apparatus, and can only be performed efficiently in a well-equipped laboratory. They are thus mainly of interest to the designer of ignition apparatus, or to the research worker engaged on ignition problems.

In the commercial testing of magnetos, present-day practice resolves itself into: (1) A determination of low-speed sparking characteristics of the machine; (2) an endurance test of many hours' duration, at a speed well above the normal working speed, to thoroughly test the mechanical and electrical components. In either case, it is clearly necessary to use some form of spark gap to transmit the succession of sparks generated by the magneto, and the choice of a suitable gap and its care in service are matters of extreme importance, which have not, perhaps, always received the attention they merit. The main purpose of the present article is to deal with this particular aspect of the general problem of magneto testing.

One frequently hears the statement that a magneto is capable of giving a spark of a certain length at some definite speed, but rarely is this statement of fact qualified by a description of the type of gap used. Unless this be done, the statement is meaningless, just in the same way that it would be absurd, when speaking of a motor vehicle, to use the number of miles per gallon of petrol as an argument for efficiency, without considering this factor in close relation to the weight, horse-power, &c., of the vehicle itself. In other words, the design of the spark gap—that is, the shape and disposition of the electrodes—is of equal importance to its mere length, in dealing with a problem of this kind. The whole subject of spark gaps and sparking electrodes is very complex, and one that is very difficult to attack experimentally, as there are so many variables involved which affect the final result, and all experimenters in this field have experienced in common the difficulty of obtaining consistent results. It will suffice, however, if we here touch on a few salient points of extreme practical importance. First, let us get back to fundamentals. A magneto produces a spark so soon as the contacts separate, by virtue of the fact that at this moment, a portion of the energy stored electromagnetically in the primary is precipitated in the secondary winding with great suddenness, producing a phenomenally rapid rise of electric pressure (or voltage) in that winding. The voltage reaches its maximum (considerably over 10,000 at normal speeds) in something like 0·0001 seconds, and the rate of voltage rise (or steepness of the wave front) immediately following the separation of the contacts, is of the order of 15,000 volts in 0·000015 seconds, or about 300,000,000 volts per second.

Now consider what happens in the spark gap whilst this sudden electric pressure is being created. The air becomes stressed electrostatically during the rapid rise of electric pressure, just in the same way that an electric diaphragm stretched across a section of a water pipe will be stretched, so soon as a difference of pressure is set up between opposite sides. Should the pressure difference increase very rapidly, in the hydraulic analogy, a point is finally reached when the diaphragm punctures, and at that moment, a flow of water occurs through it. Similarly, in the electrical case, the electrostatic stress increases with the voltage until the air "punctures," and a flow of electricity (or current) passes through the gap. The voltage at which this occurs is called the sparking voltage of the gap, and the value of this voltage naturally settles the electric strain that the machine has to endure in producing a spark at all.

It follows from the above facts that, in dealing with the sparking characteristics of a magneto we must think in terms of voltage, and a spark gap used for magneto testing should be of such design that its sparking voltage can be fairly accurately determined. It is, however, a very difficult matter to say just what the sparking voltage of a gap of known design will be under given conditions, when it is connected to a magneto, because the abnormal steepness of the voltage wave front introduces a variable factor which cannot be predetermined with accuracy. If, for example, a spark gap be connected to an alternator or transformer designed to produce about the same voltage as that generated by a magneto (say, 10,000) at the usual frequency of 50 cycles per second, the voltage is applied at a relatively slow rate, whilst if a magneto be connected to the same gap, the rate of application of the voltage will be increased enormously (probably in the ratio of about 100 : 1), and the sparking voltage will be correspondingly raised.

The two curves given in Fig. 1 should help to make this point clear. Curve 1 corresponds to a slow application of voltage. The voltage is shown to be slowly rising until the point "A" on the curve is reached, corresponding to which the air between the electrodes of the spark gap is stressed to breaking point and punctures. The voltage E corresponding to the point "A" on curve I is, therefore, the sparking voltage for these conditions. Curve 2, on the other hand, shows a very steep wave front. The voltage rises very quickly and overshoots the mark, as it were, before the point "B" is reached, at which sparking occurs. The sparking voltage is now raised to E_1 by an amount $(E_1 - E)$, and the ratio $\frac{E_1}{E}$ is termed the impulse ratio of the gap. The question of impulse ratio is of extreme importance when dealing with spark gaps for magneto testing, but even so, it is only one of the many factors which have an influence on the sparking voltage of a gap of given design.

The other factors to be taken into account are: (1) The shape and disposition of the electrodes; (2) the material of which they are made (in slight degree); (3) the nature of the gaseous medium surrounding the electrodes; (4) the density of the gaseous medium; (5) the degree of turbulence existing in the gaseous medium; (6) the direction of the current in the gap.

When testing spark gaps on ordinary alternating current circuits having a frequency of 50 cycles or 100 cycles per second the impulse ratio of any form of gap is substantially unity. Using an electrode of some definite design it is possible, in such cases, to determine with extreme accuracy the relationship between sparking voltage and gap length.

Needle-pointed electrodes are used extensively in ordinary electrical testing, and curve 1, in Fig. 2, shows how the sparking voltage is directly proportional to the gap length for a spark gap of this design, when operated in air at atmospheric pressure and temperature. To emphasize the influence which the mere shape of the electrode has on the sparking voltage, curve 2 has been added for a gap comprising spherical electrodes, each 2½ in. diameter. A gap, 5·5 mm. long, for example, has a sparking voltage of 6,000 when the electrodes are needle points, and this figure is increased three times by simply substituting for the needle points 2½ in. diameter spheres (see Fig. 3). These voltage figures correspond to a relatively slow application of voltage, and the needle point gap in particular, which has a high impulse ratio with steep wave fronts, would show a higher sparking voltage when coupled to a magneto.

Two types of spark gap, illustrated in Fig. 4, are commonly used for testing magnetos and other forms of spark generator. What is generally known as the three-point gap, shown on the top diagram, has been employed for many years past both in

Fig. 1. CURVES ILLUSTRATING MEANING OF IMPULSE RATIO.

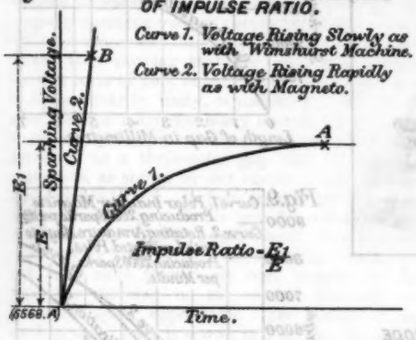


Fig. 2. SPARKING VOLTAGE CURVES FOR NEEDLE AND SPHERICAL ELECTRODES.

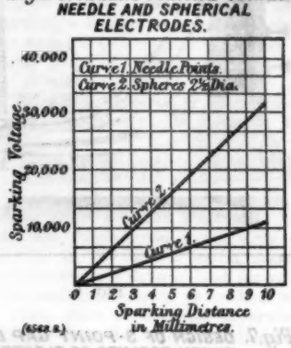
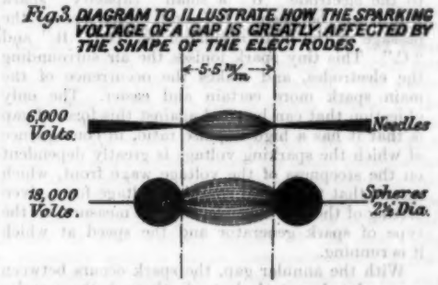


Fig. 3. DIAGRAM TO ILLUSTRATE HOW THE SPARKING VOLTAGE OF A GAP IS GREATLY AFFECTED BY THE SHAPE OF THE ELECTRODES.



Note: Sparking Voltages Correspond to Relatively Slow Application of the Pressure.

Fig. 4. THREE-POINT AND ANNULAR TYPES OF TEST GAPS

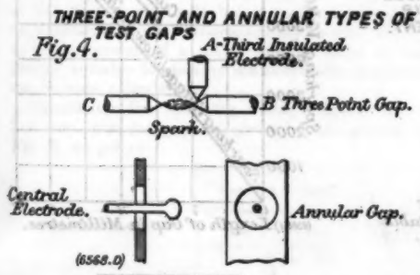
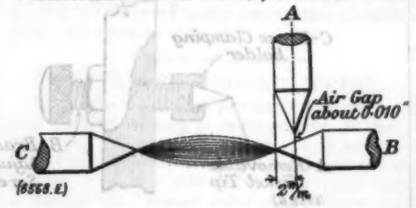


Fig. 5. DIAGRAM ILLUSTRATING CORRECT SETTING OF THIRD POINT (A) IN 3-POINT GAP.



this country and on the Continent, whilst the annular gap, illustrated in the lower diagram, is a more recent introduction. In the former design, the insulated electrode "B" is connected to the magneto, and the spark passes between it and another electrode "C," of similar design, which is earthed. The "third" insulated electrode "A" is introduced for the purpose of stabilising the gap, and making it more certain in its action. It is placed adjacent to the insulated electrode "B" so that its tip is separated by a few thousandths of an inch. The two electrodes must not touch one another, and to obtain the best results it is important that the axis of "A" lies behind the tip of "B" by at least 2 mm. The correct setting of the third point "A," which is a matter requiring careful attention, if the best results are to be obtained with this form of spark gap, is indicated in Fig. 5.

The efficacy due to the "third" point arises from the fact that so soon as a voltage is applied to the electrode "B" a small "capacity" spark will occur between "B" and "A," before the passage of the main discharge between "B" and "C." This tiny spark ionises the air surrounding the electrodes, and makes the occurrence of the main spark more certain and easier. The only objection that can be cited against this form of gap is that it has a high impulse ratio, in consequence of which the sparking voltage is greatly dependent on the steepness of the voltage wave front, which means that the actual sparking voltage for a given setting of the gap depends, in some measure, on the type of spark generator and the speed at which it is running.

With the annular gap, the spark occurs between an insulated central electrode through the annular air space formed between it and the inner surface of a hole in an earthed metal plate. The important characteristic of this gap, which accounts for its introduction, is that its impulse ratio is substantially unity if it be designed to give a ratio of $\frac{D}{d} = \epsilon$, Where,

ϵ = Base of natural logarithm = 2·718.
d = Diameter of the central stem.
D = Diameter of hole in earthed plate.

Its electrical characteristics are, therefore, somewhat more uniform than those of the three-point gap, and its sparking voltage for given conditions can be predetermined with greater accuracy. The weak point in its design is that the length of gap cannot be adjusted, although on account of the "wandering" of the spark, it has a greater life than any form of point gap.

The advantages that can be claimed for the three-point gap are: (1) The length can be easily adjusted and the sparking voltage thus varied; (2) the actual length of the gap, for some given voltage, is greater than with any other form of spark gap. Any variation in the sparking voltage due to a slight error in the setting is thus minimised; (3) by arranging the gaps one above the other (see Fig. 6) it is an easy matter to detect a missfire, when testing a multicylinder magneto, even when the speed of operation is very high. This cannot be done so readily with the annular gap owing to wandering of the spark.

It is, of course, essential that the electrodes in a three-point gap be kept sharp, and it is obviously true that owing to the concentration of the spark the electrode tips will quickly burn away, thus changing the geometrical form of the tip and the characteristics of the gap. To reduce this burning to a minimum, it is desirable to use nickel electrode tips, although iron electrodes will give quite good results.

Where gaps of this type are subjected to constant running, it is worth while using a design that permits of the conical electrode tip being quickly removed and replaced. Such a design, which the author has used with success for many years past, is illustrated in Fig. 7. The conical nickel tip "A" is clamped to the end of a brass adjustable screw "B," by a brass holder "C" which screws on to "B." By keeping a good stock of nickel tips, replacements can be made after, say, every 50 hours' continuous running of the gaps, and the tips removed can then be sharpened in a lathe and used to replenish the stock of electrode tips. This system of working has been found to yield satisfactory results.

It has already been pointed out that the three-point gap has a high impulse ratio, and on this account, the sparking voltage for a given setting when it is transmitting sparks generated by a magneto running at a high speed, is always greater than the sparking voltage corresponding to a relatively slow application of voltage to the gap. The curves given in Fig. 8 will serve to illustrate this point. The lower curve shows the relationship between the sparking voltage and length of gap, when the latter is calibrated with alternating current of normal frequency. When the gap is connected to a magneto, however, the nature of the calibration curve is entirely changed, and a recent investigation made by the writer, revealed that the shape of the curve is not only dependent on the spark frequency, but also to some extent on the magnetic and electrical characteristics of the magneto being tested. This is only natural, bearing in mind that the value of the impulse ratio is influenced by the steepness of the voltage wave front, because it is well known that this latter factor varies considerably in magnetos of different design.

Two magneto sparking voltage curves are given for a spark frequency of 2,000 per minute, curve 1 representing the results obtained with a polar inductor magneto, and curve 2 corresponding to a test made with a modern lightweight rotating armature magneto fitted with laminated poles operating in conjunction with the same gap. The general trend of each curve is the same, the most noteworthy feature being that as the length of the gap is reduced, the sparking voltage is but slightly affected.

It should be pointed out, however, that this characteristic of the three-point gap is only exhibited at very high spark frequencies. When the magneto is running at low speeds (say about 200 r.p.m.), the general trend of sparking voltage curve will more closely follow that of the lower curve in Fig. 8, although the actual voltage for any particular setting will still be somwehat higher than the figure given by this curve.

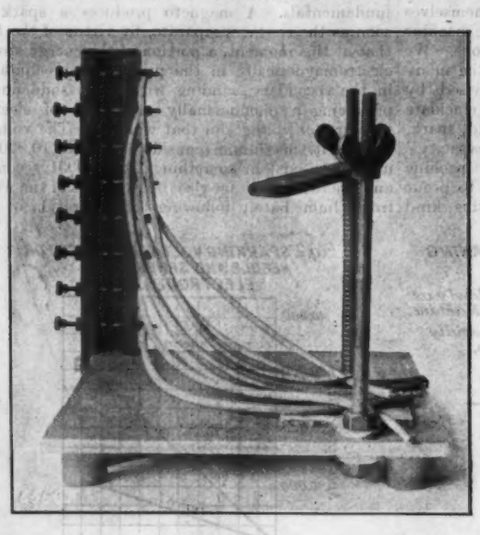


Fig. 6.

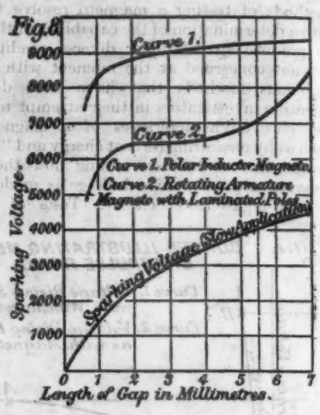
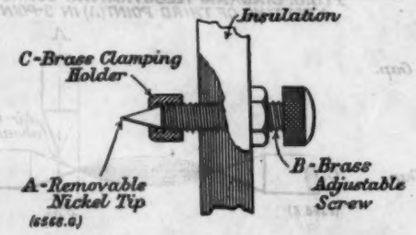


Fig. 8.

Fig. 7. DESIGN OF 3-POINT GAP ELECTRODE WHICH PERMITS OF ELECTRODE TIP BEING REMOVED FOR REPLACEMENT.



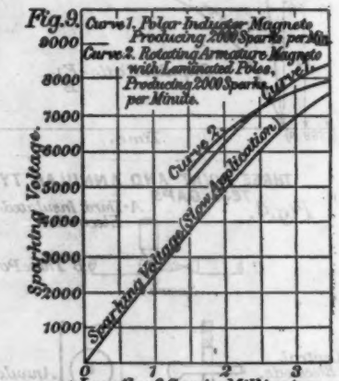
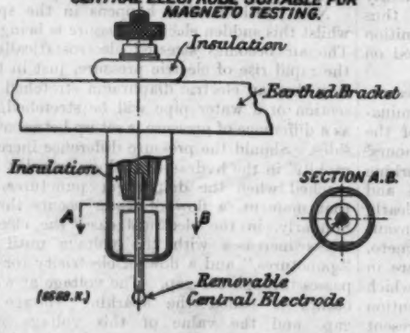


Fig. 9.

Fig. 10. ANNULAR SPARK GAP WITH REMOVABLE CENTRAL ELECTRODE SUITABLE FOR MAGNETO TESTING.



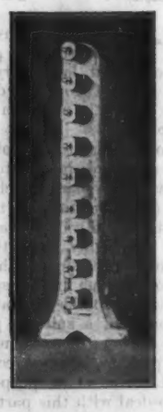


Fig. 11.

It is almost general practice when testing magnetos in conjunction with three-point gaps, to adjust the length of the gap to 5·5 mm. A reference to Fig. 8, shows that for this setting, the sparking voltages are as follows :—

Type of Magneto.	Sparking Voltage.		Impulse Ratio.
	Slow Application.	2,000 Sparks per Min.	
Laminated pole rotating armature magneto ..	4,000	7,100	1·97
Polar inductor magneto ..	4,000	9,250	2·22

Taking an average figure we get, roughly, 8,200 volts for a three-point gap, with properly-shaped electrodes, set to give a gap length of 5·5 mm.

Similar curves are plotted in Fig. 9 representing the results of tests which the writer has made on an annular type of gap, using the same magnetos as are referred to above. It is at once apparent that the magneto sparking voltage curves for both machines follow much more closely the trend of the lower curve, thus proving that the advantage claimed for this form of gap, namely, that its impulse ratio is approximately unity, is justifiable. For endurance tests on magnetos many manufacturers prefer to use annular gaps, as these do not require so much attention as a three-point gap, and the sparking voltage is, as shown by our curves, a more definite and reliable factor. In fact, tests which the writer had made on a gap of this type by running it continuously for 1,000 hours, have demonstrated that during this period, the sparking voltage did not vary more than 5 per cent. despite the fact that the burning on the central electrode was naturally quite appreciable. The design of gap used in these tests is shown in Fig. 10. It permits of the central electrode being easily removed for replacement should it become unduly burnt. Fig. 11 is a photograph of a set of annular gaps of this design, suitable for testing multi-cylinder magnetos up to nine cylinders.

Tabulating the sparking voltage figures for a 3·5 mm. annular gap, as given by the curves in Fig. 9, we get :—

Type of Magneto.	Sparking Voltage.		Impulse Ratio.
	Slow Application.	2,000 Sparks per Min.	
Laminated pole rotating armature magneto ..	7,650	8,000	1·04
Polar inductor magneto ..	7,650	8,400	1·10

Taking an average of these figures we get exactly 8,200 volts. In other words, if

Diameter of central stem = d = 1·85 mm.
Diameter of central hole = D = 8·85 mm.

then the magneto sparking voltage at high speeds will agree almost exactly with that of a three-point gap set to 5·5 mm. An annular gap of this design, or a three-point gap with this setting, would be quite suitable for use with magnetos undergoing endurance runs, as each would ensure that the voltage strain on the armature did not exceed about 8,000, which is roughly twice the voltage imposed on a magneto when it is operating under normal conditions on an engine. That is, the factor of safety would be 2 : 1, which is ample.

It is commonly believed that the only right way of determining the sparking characteristics of a magneto is to employ, as a standard test gap, a sparking plug which is fitted to a closed chamber in which the pressure of the air can be varied. The usual method is to gradually increase the pressure, by means of an air pump, until a point is reached at which, for some given speed, the magneto just ceases to produce sparks at the plug points. A gauge is provided for measuring the air pressure, and it is also necessary to provide glass windows in the pressure chamber—which incidentally are very liable to fracture—so that the sparking at the plugs can be observed. In the writer's opinion, this method of testing is cumbersome and likely to give misleading results. The prevalent idea that it enables the working conditions imposed on a magneto to be more nearly reproduced, than happens when some form of adjustable gap is used is quite erroneous. Thinking in terms of voltage, it is clear that in this method the sparking voltage, is varied by changing the air pressure, using a spark gap of some definite length, whilst with an adjustable three-point gap, for example, exactly the same result is achieved by simply varying the length of the gap. Obviously the latter method is a much simpler way of achieving the desired result.

Not only is the pressure chamber cumbersome, but its use introduces many uncertain factors. In the first place, unless steps are taken to change the air inside the chamber, it quickly becomes ionised, owing to the passage of a large number of sparks in a confined space, and as a result, the sparking voltage for a given pressure will drop. Secondly, it is apparent, from what has already been said about the various factors which influence the sparking voltage of a gap, that unless the design of the sparking plug electrodes is carefully defined, the gauge pressure cannot be taken as a criterion of sparking voltage. In a recent investigation, the writer found that the sparking voltage of standard sparking plugs of different design, varied over a range greater than 2 : 1, even when the air gaps were all made of equal length. The use of an air pressure chamber for magneto testing will, therefore, permit of a corresponding variation in the voltage strain imposed on the magneto during the test, although it is true that comparative figures can be obtained for different magnetos, if the same sparking plugs are used throughout the series of tests. The fundamental point involved is, however, that any method of testing magnetos should aim at imposing a definite load (or voltage strain) on the machine, exactly as is done when testing any other piece of electrical apparatus. Viewing the matter from this logical standpoint, it is clearly necessary to use a spark gap having well-defined sparking characteristics, and on this account, the use of either three-point or annular type of spark gap is to be preferred to any combination of sparking plugs and pressure chamber.

WELLS AND GROUND WATER.

Of all the water that percolates into the earth after rainfall, a part is re-evaporated, a part is transpired by vegetation, a part escapes as surface flow, and the remainder percolates downward into the soil until it is held up by impervious strata, or reaches the "ground water plane," below which every pore space of the soil, every crevice, hollow and fissure in the earth's crust is filled with water, and the escape laterally of the ground water equals the addition from percolation. The lowest level of escape is generally the level of the sea, below that level the soil and rocks are saturated. The depth of percolation of ground water into the earth is not known, it may reach even as far as the intensely heated interior of the earth, as capillary water has the capacity of penetrating rocks even against high counter pressure of vapour. Within the earth the "ground water" is in constant circulation, through the pore spaces of rocks, through fissures, and through channels along joints, evincing its power as a geological agent by its chemical and mechanical actions.

The amount of supply to ground water is dependent on the rainfall, and the laws which govern the flow of water through the soil, which may be by gravitation, or by capillary action. There are other factors also which influence its flow; the passage of a low barometric depression across a section of the country is always associated with a more rapid discharge of water from springs, flowing wells, and seepage outlets; the eruptions of volcanos are often preceded by a failure or diminution of the supply from wells and springs in the district; the rate of seepage is modified by changes in soil temperature; the settling of silt and fine sediment over coarser beds as consolidation takes place partly by compression, and partly by accumulation of sediment, causes the water contained in the coarser beds to be expelled upwards, downwards, or laterally. The supply of ground water is practically that due to (1) Percolation from rainfall; (2) seepage from streams and rivers; (3) seepage from pools, lakes and standing water. The losses to ground water are (1) soil evaporation; (2) transpiration by vegetation; (3) escape of ground water as surface flow at depressions, which may again increase the ground water lower down by percolation, or eventually reach the sea. The most important losses are by soil evaporation, and transpiration by vegetation; were it not for these losses the volume of streams flowing into the sea would be greatly increased.

Except in arid regions, the mantle of soil, sand, gravel and clay which nearly everywhere covers the surface of land areas carries a surprisingly large amount of water. After rain the inter spaces of the soil will become uniformly occupied with water and gas, if the rate of fall is greater than the rate at which the water can pass through the pore spaces of the soil, it remains on the surface as pools, or runs off the ground as surface flow. After seepage or the drainage of the water through the soil to the ground water plane has ceased, there will be found, provided the soil is uniform, commencing from the surface, an increased quantity of water in each successive layer of soil; that is the water concentration in the soil in pounds per cubic foot will increase with the depth of the soil. The water-retaining power of a soil is closely related to the total surface area of the soil particles per cubic unit; if a coarse and a fine soil are in contact, not one superimposed above the other, the quantity of water held in the coarse soil will be less than that held in the fine one, that is the capacity of holding water of the two soils depends on the number and size of the capillary spaces of the soils. By capillary space is meant that space which is near the point of contact of two soil grains and not any interstitial space in the soil. In a soil of fine texture the soil grains might be so close together as to make all the interstitial spaces capillary. The surface of the soil particles being clean, water has no difficulty in flowing over the surfaces. The water by capillary action clings to the soil grains in the form of films, one surface being in contact with the soil grain and the other exposed to the air. As the surface of the land dries the water near the surface is evaporated the curvature of the water films in the immediate neighbourhood will thereby be increased, and water will be drawn up from the next lower layer, and so on.

It takes time for the water to move up these various layers. When rain falls on a dry soil the surface tension is diminished and the greater tension below pulls the moisture down, even when the force of gravity would not be sufficient to do so; if the fall is light, the moisture, after penetrating some distance, is again re-evaporated when the upper surface dries. Water held in the soil by surface tension is called the water of inhibition, or quarry water; if more water enters the soil, the film thickens until finally, when saturation is reached, all the spaces between the soil particles are filled with water, surface tension is reduced to zero, and gravity alone acts on the water. When this limit of the capacity of any soil for holding water is reached water will flow, and becomes "ground water" or the "water of saturation."

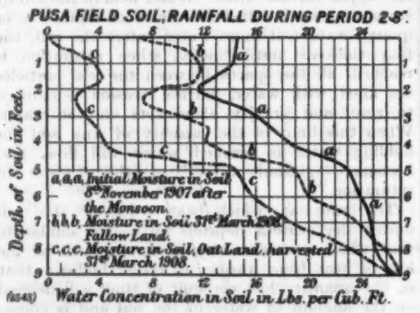
The rate at which water leaves the soil during dry periods depends on a law similar to that which governs many processes, such as the loss of heat from warmer to cooler bodies; that is, the quantity lost per unit of time will depend on the amount of water in the soil and is consequently greater after rain. It is influenced by changes in temperature and varies inversely with the humidity. A soil possessing a greater surface area of soil particles per cubic unit will lose water less rapidly than one possessing a less surface area of soil particles per cubic unit, i.e., a soil possessing not more than 2,000 sq. cm. surface area of soil particles per cubic centimetre will lose water more rapidly than a soil possessing 4,000 sq. cm. to 6,000 sq. cm. total surface area of soil particles per cubic centimetre. In the case of sand, conditions vary; sand and sandy soils not exposed at the surface lose water rapidly, but when exposed at the surface, at first the loss will be rapid, but this class of soil dries so effectually at the surface that several inches may become air dry. The soil in which surface tension is able to act is therefore protected by a layer of dry material through which water passes

as a gas by diffusion, and not in a liquid form by surface tension, and this process is extremely slow. Mr. E. Buckingham, in Bull. 38, United States Department of Agriculture, states that in an experiment the loss by gaseous diffusion through 2 in. of dry sand amounted from 1·4 in. to 4·3 in. in twelve months; consequently, after the surface 2 in. or 3 in. of a sandy soil have become really air dry, the rate of loss from soil evaporation is very small. A large area, and great depth of sand, forms therefore a natural reservoir.

The depth from which water tends to move upwards through the soil varies with its texture and structure. It may be said broadly that under average conditions capillarity acts freely from 4 ft. to 5 ft. in depth, fairly up to 10 ft., and extremely slowly from 30 ft. or more. Dr. King, in the Nineteenth Annual Report, Part II, United States Geological Survey, states that where the surface soils are very coarse and where the "ground water" is at a depth exceeding 8 ft., nearly the whole rainfall passes at once below the level at which it is possible for capillary action to bring it to the surface. In experiments made by Dr. Leather in alluvial soil, at Pusa, North India, composed of 2 ft. of loam, and next 2 ft. of sandy loam, and below that 12 ft. of stiff clay, 7 ft. was the limit of depth from which water tended to move upwards. Beyond this depth "ground water" had no influence on the amount of evaporation.

Mr. Lee ("Yield of Underground Reservoirs," P.Am.I.C.E., vol. lxxviii, 1915) states that where the average depth of "ground water" does not exceed 8 ft., soil evaporation coupled with transpiration from vegetation forms an important element of loss of ground water. Transpiration by vegetation increases the loss of water from the soil. The amount of water required for a crop equals the amount transpired by the crop plus the soil evaporation during the crop period. If the crop is a "good crop" the soil evaporation will be about half what it would have been in open fallow land. In Pusa soil, Dr. Leather estimates the amount of water consumed by a wheat crop, November to March, to be equal to 10 in. to 11 in. on the ground, of which the soil evaporation during the period was 2½ in. to 3½ in., the difference being the amount transpired by the crop. In Cawnpore soil, which contains more clay and is stiffer than Pusa soil, a five-month winter crop of wheat, November to March, consumed 20-in. depth of water on the ground, including irrigation. The actual amount transpired by the crop was about 9 in. to 10 in.; the irrigation increased the soil evaporation.

The diagram annexed indicates the amount of water consumed by an oat crop, compared with


PUSA FIELD SOIL; RAINFALL DURING PERIOD 2-8".
Depth of Soil in Feet.
a,a,a, Initial Moisture in Soil 8th November 1907 after the Monsoon.
b,b,b, Moisture in Soil 31st March 1908. Fallow Land.
c,c,c, Moisture in Soil, Oat Land, harvested 31st March 1908.
Water Concentration in Soil in Lbs. per Cub. Ft.

the soil evaporation from fallow land during the same period. The vertical scale shows depth of soil in feet, and the horizontal scale gives the water concentration in the soil in pounds per cubic foot for each foot in depth ("Memoirs of the Department of Agriculture in India," Chemical Series, vol. i, No. 10). Grass lands consume a considerable amount of water, while on the other hand forest cover, more especially the litter of a forest, may decrease soil evaporation to nearly seven-eighths of that in an open field, due to impeded air circulation, low temperature, and the moist condition of forest air. The following figures may be taken as giving a general indication of the total losses of water from the soil due to vegetation: Grass lands, 30 in. to 40 in. a year; dry grain crops, 10 in. to 15 in. during their season; forests, 4 in. to 8 in. a year.

The depth at which "ground water" is found below the surface of the soil influences the soil evaporation. Experiments made by Dr. King (Nineteenth Annual Report, United States Geological Survey, Part II, 1897–98) gives the following figures showing the amount of evaporation from 1 sq. ft. surface of fine sand for various depths of ground water:—

Ground water 1 ft. below surface. Evaporation 2·37 lb. per day.
Ground water 2 ft. below surface. Evaporation 2·07 lb. per day.
Ground water 3 ft. below surface. Evaporation 1·23 lb. per day.
Ground water 4 ft. below surface. Evaporation 0·91 lb. per day.

With clay-loam the following results were obtained:—

Ground water 1 ft. below surface. Evaporation 2·05 lb. per day.
Ground water 2 ft. below surface. Evaporation 1·62 lb. per day.
Ground water 3 ft. below surface. Evaporation 1 lb. per day.
Ground water 4 ft. below surface. Evaporation 0·90 lb. per day.

Mr. Lee ("Yield of Underground Reservoirs," P.Am.I.C.E., vol. lxxviii, 1915) gives the following results of observations made at Independence, Seira Nevada, in 1911.

Depth of ground water 1·45. Evaporation, twelve months, 48·80 in.
Depth of ground water 1·86. Evaporation, twelve months, 44·89 in.
Depth of ground water 2·90. Evaporation, twelve months, 40·21 in.
Depth of ground water 4·94. Evaporation, twelve months, 13·43 in.
Temperature of air, 40 deg. to 80 deg. F.

In the same paper Mr. Lee gives the loss in inches from ground water in grass and alkali land:—

Depth of Ground Water below Surfaces.	Loss in ins. from Ground Water.		Total.	——
	Summer Average Temperature 70 deg. F.	Winter— Average Temperature 45 deg. F.		
ft.			ins.	
2·5	36·5	5·2	41·7	Summer, April 1 to Sept. 30. Winter, Oct. 1 to Mar. 31.
3·5	29·6	4·0	33·6	
5·5	15·6	0·2 ft.	15·8	

The following are results of experiments on percolation and soil evaporation. In Pusa soil, which forms part of the Gangetic alluvium, which is exceptionally fine, with a low percentage of pure clay highly calcareous, and which holds 25 lb. of water per cubic foot after drainage has ceased, Dr. Leather found the loss by soil evaporation on fallow and, from September 19, 1906, to June 15, 1907, to be 20 in. The effect of light falls of rain during this period was to increase the water in the first foot of soil without penetrating deeper and eventually to increase the rate of evaporation. The temperature varied from 60 deg. to 90 deg. F. The rainfall recorded at the place during the period was as follows:

	In.
September 19 to October 20	0·95
October 21 to January 7	nil
January 8 to February 15	1·4
February 16 to March 27	1·85
March 28 to April 9	nil
April 10 to April 30	0·89
May 10	0·33
June 1	1·75
Total	7·17

In the same soil the following results were obtained on drainage through 6 ft. of soil:—

Data.	Rainfall.	Drainage.	Surface Flow.	Evaporation from Soil.
Fallow land—	in.	in.	in.	in.
Nov. 1, 1906–Oct. 31, 1907 ..	39·72	6·96	4·02	28·74
Nov. 1, 1908–Oct 31, 1909 ..	75·70	28·36	8·32	30·46
Nov. 1, 1909–Oct. 31, 1910 ..	32·30	6·41	—	25·89
Cultivated with maize—				
1906–1907	39·72	4·64	0·85	34·23
1908–1909	75·70	32·48	1·24	41·96

The cultivated land in both cases reduced the surface flow. The drainage increased with the rainfall. The soil evaporation increased to a certain extent with the rainfall.

In Cawnpore soil, consisting of fine earth more clayey than Pusa soil and possessing an ordinary proportion of lime with irregular beds of nodular limestone, the following results were obtained on percolation experiments through 6 ft. of soil:—

Date.	Rainfall.	Drainage.	Flow.	Soil Evaporation.
Fallow land—	in.	ins.	in.	in.
Nov. 1, 1903–Oct. 31, 1904 ..	46·51	21·22	4	21·29
Nov. 1, 1904–Oct. 31, 1905 ..	20·61	3·14	nil	17·47
Nov. 1, 1905·Oct. 31, 1906 ..	36·49	19·13	,,	17·44
Nov. 1, 1906–Oct. 31, 1907 ..	20·89	3·04	,,	17·25
Nov. 1, 1907–Oct. 31, 1908 ..	32·66	14·56	,,	18·10
Cultivated Land—				
1909–1910	28·35	4·35	,,	23·82

Experiments in America with various soils having depths 3 ft. to 4 ft. give the following results:—

Rainfall 26 in. Soil, sandy loam with vegetation, percolation 40 per cent.
Rainfall 25 in. Soil, sand without vegetation, percolation, 83 per cent.
Rainfall 31 in. Soil, loam and clay without vegetation, percolation 43 per cent.
Rainfall 25·7 in. Soil, loam and clay with vegetation, percolation 26 per cent.

The Rothamsted experiments give the following results:—

Rainfall 41 in., percolation 25 in., evaporated 16 in.
Rainfall 19·5 in., percolation 6 in., evaporated 13·5 in.
The percolation varies directly with the rainfall.
The evaporation is nearly constant.

W. Charles Greeves, in his experiments at Lee Bridge (Proceedings of the Institution of Civil Engineers, vol. xlv), from an average of fourteen years, arrives at the following results:—

Rainfall 25·721 in. Percolation through soil 7·582 in.
Rainfall 25·721. Percolation through sand 21·496 in.

To summarise: Percolation or the supply to the ground water depends on the rainfall, porosity of strata pierced through, and extent of exposed surface. It varies inversely with the soil evaporation; is greatest in winter and during heavy, long-continued rains; it is least in summer with short showers of rain. The deficiency of ground water will be felt most towards the close of a long dry season where the reserve of water furnished by the rains of the preceding rainy season have been reduced to their lowest limit, by the demands of the dry months. A failure of rain, or scanty rainfall during the rainy season is therefore more likely to cause a diminution of ground water, or a drought, than a long dry summer.

The quantity of water any particular soil or rock may yield does not depend on the quantity of water required to completely saturate the soil or rock. The water capable of being drawn off is that which the soil or rock contains over and above that which it is able to hold as water of inhibition, and the readiness with which the soil or rock will yield a supply when drawn on. Sand will hold 0.459 cub. ft. of water for a cubic foot of sand when fully saturated, but the whole of this amount will not be available for supply. The yield will probably be from 1·87 gallons to 1·31 gallons per cubic foot. Colonel Clibborn (Roorki Treatise on Civil Engineering. Irrigation Works in India, 1901), states that the "Actual quantity of water an underground sandy reservoir will hold depends on the character of the soil. It may be assumed at one-third the bulk of the sand, of which not more than one-quarter will drain in at once when a well is drawn on."

In the case of chalk the water of saturation equals 35 per cent. of the bulk of the chalk, or about 2½ gallons per cubic foot. The water of inhibition or quarry water equals 19 per cent., or 1·2 gallons per cubic foot. The yield, therefore, that may be expected from saturated chalk will be about 1 gallon per cubic foot. Chalk, however, has the peculiarity of readily absorbing water but parting with it slowly. The yield from wells sunk in chalk is chiefly obtained from fissures and joints tapped by wells or by adits driven from them.

Except in desert areas where the rainfall is

60-B.H.P. HOT BULB MARINE ENGINE AT THE GLASGOW EXHIBITION.

CONSTRUCTED BY MESSRS. PLENTY AND SON, LIMITED, ENGINEERS, NEWBURY.

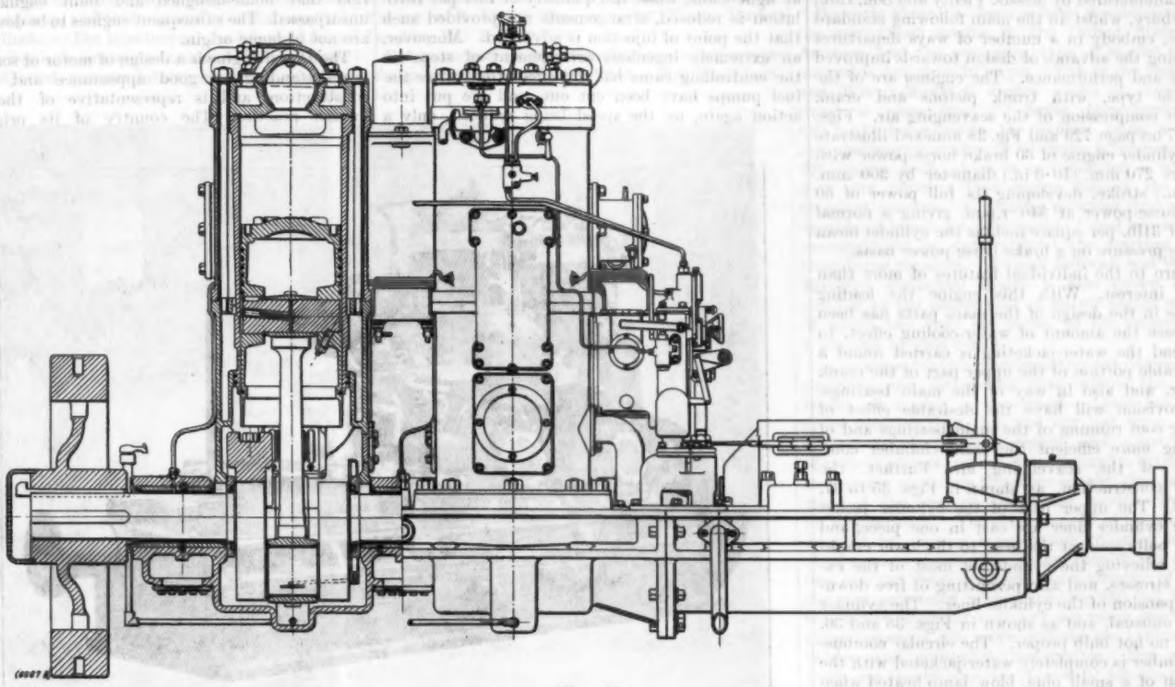


FIG. 35.

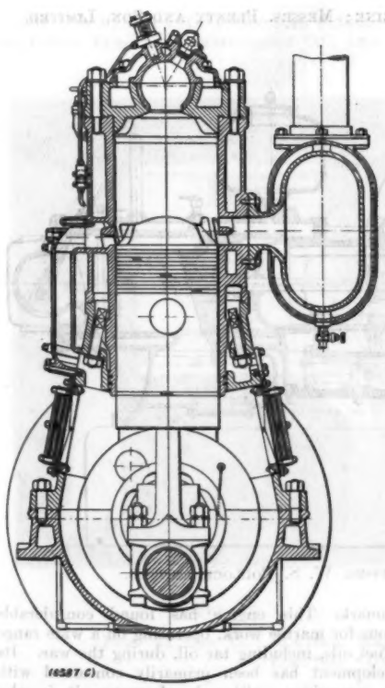


FIG. 36.

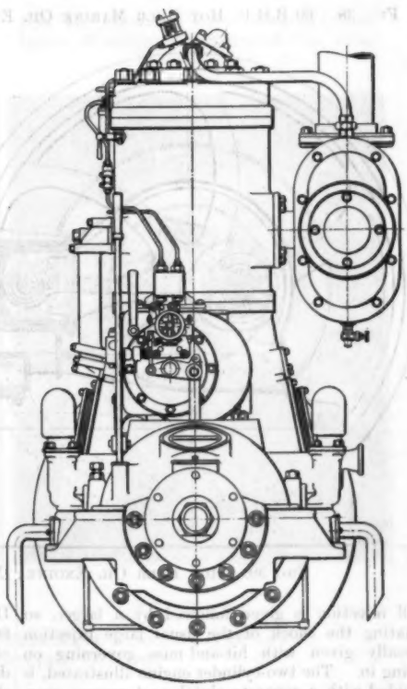


FIG. 37.

nominal, the "Recent" alluvial deposits yield inexhaustible supplies of water, which is contained chiefly in the beds of porous material such as sand or gravel. Large areas of sand such as the sand dunes in Holland provide sufficient water for a "town water supply," the only source being that portion of the rainfall of the district which has percolated to the ground water. In the small island of Rameswaram, separating India from Ceylon, where the great temple dedicated to Rama attracts numerous pilgrims from all parts of India, a supply of potable water for the town of Rameswaram is obtained from a large waste sandy area a few feet above the level of the sea, bounded on the east and north by sand-blown hills, and on the west and south by the sea. Here the rainfall of past years has collected and formed a great basin of fresh water in the sand, exceeding in places a depth of over 20 ft. below sea level.

In the case of the older geological formations disintegrated and decomposed rock yields a limited supply of water. The hard igneous rocks appear, on the whole, to disintegrate, more easily than rocks of sedimentary origin, the disintegration of igneous rocks often extending to a depth of over 100 ft. Where wells are sunk below the level of disintegration, or where the depth of soil over the solid rock is small a supply of water is obtained along the joints and fissures which traverse these rocks. In South India, in the Chittore district and the adjacent Mysore plateau, where the rainfall is comparatively scanty, and where only a small depth of soil overlies the hard granitoid gneiss, which forms the base rock of the peninsula, the ryat or cultivator sinks wells into the granitic rock and obtains a supply in most years sufficient for irrigation. Village tradition based on the experience of successes and failures of past generations enables him to select sites for his wells, where he is most likely to tap fissured rock. The supply to such a well is generally increased by throwing an earthen embankment across the valley, above the well, so as to form a small tank or reservoir, thereby preventing the rainfall running off the ground, and increasing the percolation to the well. Such areas suffer when a failure of rain occurs, and the evils of a possible famine are often aggravated by a scarcity of water for drinking purposes, both for men and animals.

In rocks of sedimentary origin, the more porous sandstones yield a fairly copious supply. In most other rocks the supply is chiefly obtained from channels opened in fissures and joints of the rock, by the chemical and mechanical actions of ground water.

THE SHIPBUILDING, ENGINEERING AND ELECTRICAL EXHIBITION AT GLASGOW.

(*Continued from page* 700.)

IN this further notice of the Glasgow show, which closes to-morrow, we propose to deal in the first instance with some of the important internal-combustion engines which we did not refer to last week, and to then add an account of other of the interesting exhibits of a more miscellaneous kind which we have not yet dealt with. Referring then in the first place to the question of engines, it may be said that whilst the general trend of

design of semi-Diesel engines was shown in the illustrations of this type of prime mover in our article last week, there are individual features in each maker's design. For example, the semi-Diesel engines manufactured by Messrs. Plenty and Son, Ltd., of Newbury, whilst in the main following standard practice, embody in a number of ways departures evidencing the advance of design towards improved practice and performance. The engines are of the two-cycle type, with trunk pistons and crank chamber compression of the scavenging air. Figs. 35 to 37 on page 729 and Fig. 38 annexed illustrate a two-cylinder engine of 60 brake horse-power with cylinders 270 mm. (10·6 in.) diameter by 300 mm. (11·8 in.) stroke, developing its full power of 60 brake horse-power at 340 r.p.m. giving a normal figure of 31lb. per square inch as the cylinder mean effective pressure on a brake horse-power basis.

To turn to the individual features of more than passing interest. With this engine the leading principle in the design of the main parts has been to increase the amount of water-cooling effect, to which end the water-jacketing is carried round a considerable portion of the upper part of the crank chamber, and also in way of the main bearings. This provision will have the desirable effect of assisting cool running of the main bearings and of rendering more efficient the crank-chamber compression of the scavenging air. Further, the cylinder construction, as shown in Figs. 35 to 37, is novel. The upper part of the cylinder jacket and the cylinder liner are cast in one piece, and through bolts connect the head to the lower crank-case, so relieving the cylinder of most of the expansion stresses, and also permitting of free downward expansion of the cylinder liner. The cylinder head is unusual, and as shown in Figs. 35 and 36, there is no hot bulb proper. The circular combustion chamber is completely water-jacketed with the exception of a small plug, blow lamp heated when starting the engine from cold, and upon which the starting injector sprays the fuel for the initial cycles. This starting injector is supplied with fuel from the fuel pumps by means of a by-pass valve and connection opened for starting.

When the engine has commenced to fire, the by-pass is closed and the main spring-loaded injector takes up the work. This injector sprays downwards on to a loose spherical sleeve inserted into the bottom half of the circular combustion space. Sufficient heat is retained by this sleeve to support combustion continuously at all loads. The arrangement is such that during normal running the starting injector is protected from the main fuel spray, since it does not pass through the loose sleeve in the combustion space. The consumption of fuel oil guaranteed with these engines, based on oil of specific gravity of about 0·860, and having a calorific value of not less than 19,000 British thermal units, is 0·57 lb. per brake horse-power per hour in the case of the 30 brake horse-power unit and 0·517 lb. with the larger engines of 50 brake horse-power per cylinder. These figures are stated with 10 per cent. tolerance and give evidence of the efficiency of the combustion arrangements.

With all the makes of hot-bulb oil engines at present on the market the most outstanding feature is the great variety of designs of oil-feeding arrangements. A remarkable point also to be mentioned is the extreme ingenuity displayed in the various designs put forward and methods of construction adopted to meet the present requirements. The semi-Diesel engine is a compromise, the whole object of which is to produce an engine of simple and robust construction, capable of being handled without a high class of supervision. Yet, in the main, the requirements of fuel feeding demand a mechanism the reverse of simple and somewhat delicate in adjustment and repair. The chief considerations with which the designer is faced, are to provide a mechanism for control of the quantity and time of injection of the fuel suitable for the range from no load to full load. The engine must be governor-controlled as well as hand-controlled. Means are required to prime the fuel pumps prior to starting. The adjustments for facilitating slow running are preferably arranged so that the point of injection of the fuel is advanced for slow running.

With the two-cylinder Plenty engine the pumps are driven by an eccentric off the crankshaft; and as is usual, this also drives the bilge and circulating water pumps. Governing is by hit-and-miss and at light loads, when the quantity of fuel per revolution is reduced, arrangements are provided such that the point of injection is advanced. Moreover, an extremely ingenious arrangement of steps on the controlling cams has the effect that, after the fuel pumps have been cut out, and are put into action again, on the speed being reduced, only a small injection is given followed by a larger, so obviating the shock of the usual large injection generally given with hit-and-miss governing on cutting in. The two-cylinder engine illustrated, is provided with a separate clutch and reverse gear, supplied complete with the engine. The three and four-cylinder units, by the same maker, are somewhat different in design so far as the fuel-feeding mechanism is concerned. The pumps are driven by a vertical shaft obtaining its motion from the crankshaft through special gearing. This vertical shaft serves also to drive the starting air distributor for direct reversal.

The three types of oil engines described in the present and last week's article are of British origin, design and construction. In all respects they go definitely to show that although this type of prime mover originated here many years ago, and was then developed abroad and neglected at home, there is evidence that we have now reached such a stage in semi-Diesel engine design and construction that home-designed and built engines are unsurpassed. The subsequent engines to be described are not of home origin.

The Densil engine is a design of motor of some six years standing, of good appearance and sound construction, and is representative of the best foreign practice. The country of its origin is Denmark. This engine has found considerable favour for marine work, operating on a wide range of fuel oils, including tar oil, during the war. Its development has been primarily concerned with ship propulsion, although of course it is also applied to land work. In the four-cylinder model, developing 100 brake horse-power, there are several noticeable features. This engine has only a small portion of the combustion chamber uncooled, and so can remain stopped for some minutes without becoming sufficiently cold for a restart to require the blow lamps as for initial heating. The type of air valves in the crank chamber doors is very neat. They are formed of short lengths of saw-blade steel. The lubrication arrangements with the force feed multiple-plunger box for such cylinder are very thorough. The

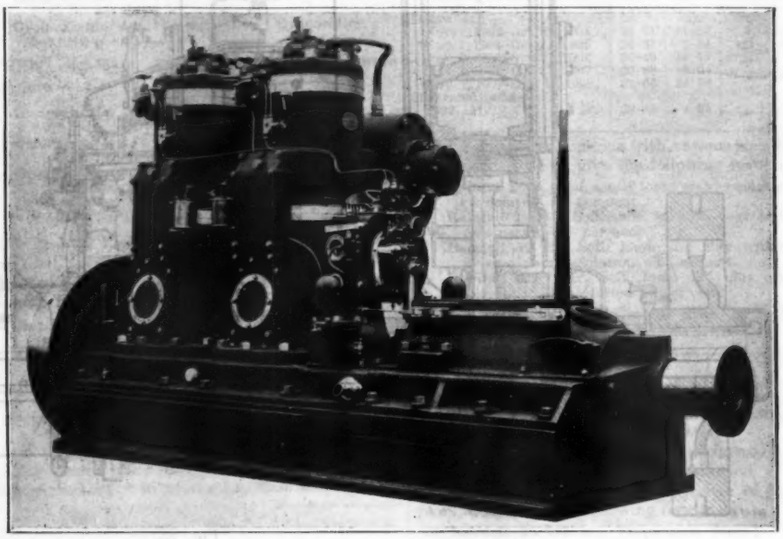


FIG. 38. 60 B.H.P. HOT BULB MARINE OIL ENGINE; MESSRS. PLENTY AND SON, LIMITED.

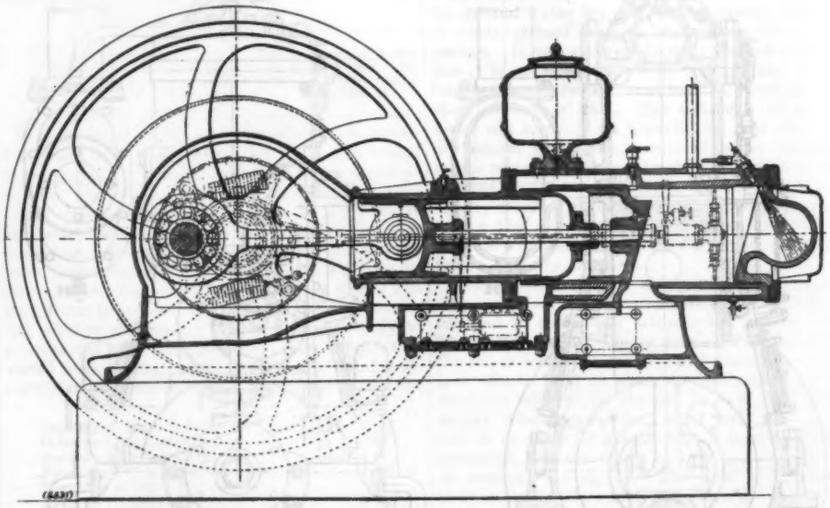


FIG. 39. HOT BULB OIL ENGINE; MESSRS. W. S. POLLOCK AND CO.

governor and the fuel pumps are driven from the crankshaft, by a vertical shaft through spiral gearing. Governing is not on the hit-and-miss principle, but is effected by regulating the stroke of the fuel pump, and so the quantity of fuel supplied to the cylinder. The injectors can be detached from the cylinders by unscrewing one nut. The governor can be adjusted to come into operation at a higher or lower speed by the hand wheel situated on the top of the governor spindle.

For small sizes a reversible propeller or a separate reverse gear and clutch is provided. The larger engines, however, are directly reversible on air, a shaft running fore and aft with ahead and astern cams and levers operating in sequence on an air-admission valve in each cylinder. The central hand wheel, when rotated, reverses the fulcrum shaft of these levers and brings the air cams into operation, and the fuel pumps also into sequence. This type of engine is made in one, two, three and four-cylinder types, from 10 brake horse-power to 240 brake horse-power, and in the larger sizes is guaranteed not to exceed 0·55 lb. per brake horse-power consumption of fuel oil. The representatives for this engine in this country are the Safix Marine Engine and Motor Company, 16, Bevis Marks, London, E.C. 3.

Reference was made last week to the only example of separate scavenging exhibited. This small horizontal engine is shown in Fig. 39. The main piston has a piston rod, and the crosshead forms the piston of the scavenging pump. By this means the crank chamber can be either left open and very accessible, as in this case, or can be force-lubricated throughout. In respect of this separate combined scavenging pump and crosshead this engine follows a practice which is gaining ground in America. The other features of this engine, the retention of the water drip, the low compression and the large hot-bulb present no novelty. The bottom end of the main bearings have ball bearings, and a shaft governor controls the strokes of the fuel and water pumps. The other features of the engine, which is shown by Messrs. W. and S. Pollock and Co., of 73, Robertson-street, Glasgow, will be quite apparent from an inspection of the illustration.

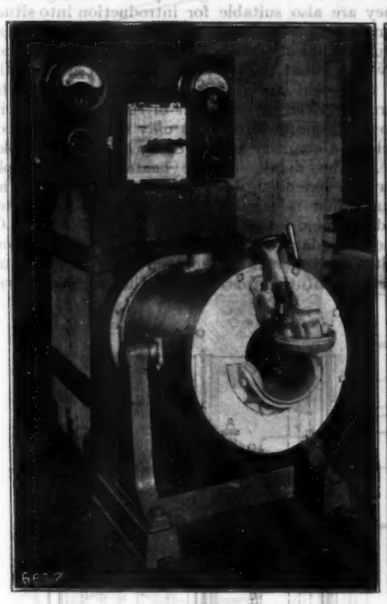


FIG. 40. NON-FERROUS METAL-MELTING FURNACE; THE LEEDS ELECTRIC CONSTRUCTION CO., LTD.

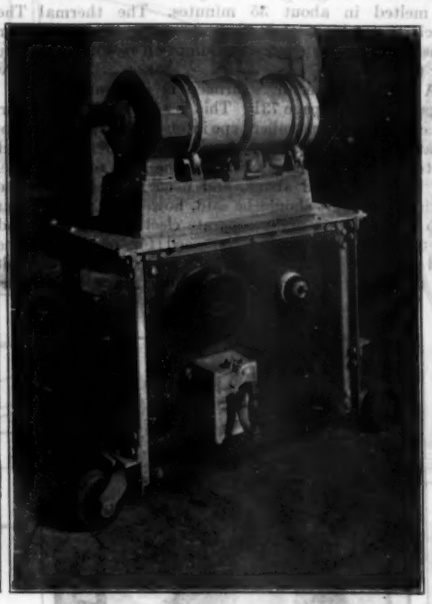


FIG. 41. ELECTRIC RIVET HEATER; THE LEEDS ELECTRIC CONSTRUCTION CO., LTD.

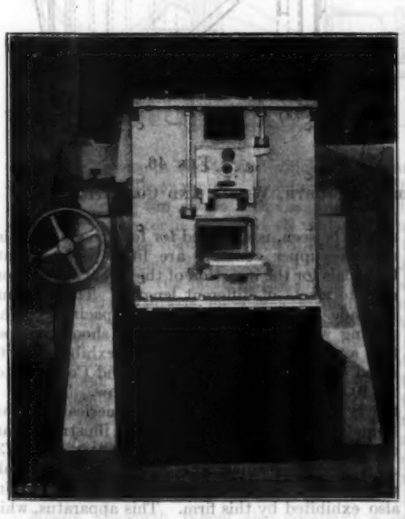


FIG. 42.

FIG. 43.

FIGS. 42 AND 43. ELECTRIC HEAT-TREATMENT FURNACE; THE LEEDS ELECTRIC CONSTRUCTION CO., LTD.

Recently there has been a large development of the semi-Diesel engine in the United States of America, and the remaining type of engine to be noticed is American in origin. This is the Babcock and Wilcox-Munktell engine which is manufactured in sizes from 10 brake horse-power to 500 brake horse-power, the exhibit being a two-cylinder marine engine of 50 brake horse-power at 375 r.p.m., with which is incorporated a reverse gear and clutch. This engine follows the best standard practice; it requires no water drip and is capable of burning a wide range of fuel oils and of running light or slow without the starting blow lamp being required. A small Babcock and Wilcox Munktell horizontal engine is also shown incorporated as the power unit of an oil engine winch, of which two sizes are made, to lift respectively 1 ton and 1½ tons direct.

In no respect is this representative exhibition more complete and interesting than where the semi-Diesel oil engine is concerned. Apart from the types mentioned in this and our last issue, there are others of excellent design and construction of various powers and duties. Naturally, in Glasgow the marine market is the more sought after, and so most of the engines shown are models designed for marine work. The great variety of the methods adopted by various constructors to meet marine requirements shows clearly that finality in design has not yet been reached. In a number of cases the gear associated with regulating the fuel feed is too complicated for ordinary sea-going work. In other instances, the more delicate mechanisms are hidden and somewhat inaccessible. For marine work, we would urge the necessity for simplicity, robustness and accessibility. Where marine engines have been developed from land practice, adverse criticism on these three counts can generally be made.

Turning now to more miscellaneous exhibits we may first refer to an interesting series of electric furnaces shown by the Leeds Electrical Construction Company, Limited, of Charmouth-street, Leeds. Of these perhaps the most novel is the electric rivet heater shown in Fig. 41, annexed. Electric rivet heaters of the type in which the rivet itself forms part of a secondary electric circuit, have been brought forward somewhat prominently during recent months, but in the matter of heat regulation and current consumption the type shown in the figure would appear to possess qualifications of importance. In this form it is impossible for the rivets to become overheated, and at the same time energy loss owing to radiation is to a large extent eliminated.

The arrangement consists of a rotary furnace with a central tube open at the ends. The central tube is made of refractory material said to be capable of standing a temperature of up to 1,600 deg. C. without softening or distortion. This tube is heated by a winding of resistance alloy outside it, the winding being protected by the outer cover which can be seen in the figure. This cover is of metal, and forms part of a complete earthed metallic protection which encloses all electrical gear and connections. The rivets which are to be heated are placed in the central tube at one end and emerge at the other, raised to the requisite temperature. The method by which the rivets are traversed forward in the tube is extraordinarily simple. The whole furnace continually rotates, being driven by a small motor and the worm gearing which can be seen in the figure, and the rivets are fed into the tube shank end foremost. When a rivet lies in this way at the feeding end of the tube the rotation of the furnace tends to carry it round with the inner surface of the central tube. The rivet accordingly mounts on to the slope until a point is reached when the contact friction can no longer sustain it, and it rolls down. The rivet is, of course, resting on the head and on the point, and owing to the greater diameter of the head when it rolls it pivots to some extent on the small end, and the result is that it travels forward bodily a slight distance in the tube. When the rivet comes to rest, it is again

lifted by the rotation of the tube, again rolls down and travels forward and so on, the effect being a gradual translation towards the far end of the tube, in a series of steps.

We have seen this automatic travelling of the rivets in operation and it appears to work perfectly. When the rivets reach the far end of the tube they may either be removed with tongs, or allowed to fall into a receptacle. The speed of travel of the rivets depends naturally on the speed of rotation of the furnace, but it depends also on the ratio between their diameter and length, the longer rivet travelling more slowly, as will be clear from what we said about the mechanism of the operation. This is, of course, exactly what is required, the longer rivets demanding a longer heating time. An additional control over the heat attained by the rivets is provided by a control gear regulating the heat of the furnace winding. The time taken by the heater to reach its maximum temperature, from first switching on, is approximately 25 minutes, and the furnace is able to heat four ⅞ in. diameter rivets per minute. This applies to the size of furnace intended for dealing with rivets of this size as a

Fig. 44. Electric Rivet Heater; The A.C., Cutting and Welding Co., Ltd.

maximum. This furnace on a test heated 240 ¾-in. rivets, 2 in. long, with an expenditure of energy of 5 Board of Trade units. This included the current supplied for driving the motor.

It should be said that the rivet heater, in common with other furnaces manufactured by the Leeds Electrical Construction Company, is known by the name of "Lecfur." Another furnace made by the firm is illustrated in Fig. 40, page 731. This shows a non-ferrous metal melting furnace of the resistance type. As will be gathered from the figure, the furnace is of the cylindrical vertical type carried on a cast-iron stand and arranged to tilt for pouring. The tilting gear is so arranged that the furnace is self-sustaining in any position. The refractory material of the melting chamber is capable of standing temperatures up to 1,600 deg. C., is chemically inert and has no reaction with non-ferrous metals, while the heating element is of an alloy with a melting temperature of 1,500 deg. C. It is wound in intimate contact with the outside of the melting chamber. The space between the chamber and the outer shell of the furnace is filled with heat insulating lagging. As will be seen, a pouring spout lined with refractory material is provided on the furnace, and also a lined cover operated by a worm gear. Among the advantages of carrying out the melting of non-ferrous metals in a furnace of this type are the extreme accuracy of temperature control and the fact that the metal is heated in what is practically a non-oxidising atmosphere. Losses due to oxydation and vapourisation are reduced to a minimum. The rate of melting naturally depends on the metal being melted and the capacity of the particular furnace used, but as an average figure it may be said that brass is melted in about 35 minutes. The thermal efficiency is high, and when melting commercial brass the average energy consumption is 400 units per ton.

A further "Lecfur" furnace is illustrated in Figs. 42 and 43, page 731. This is a resistance furnace of the twin chamber type intended for the heat treatment of metals. The electrical and other detail features of the furnace follow on the lines of those we have described about, and need not be dealt with further. It should be said, however, that the two chambers are under separate electrical control, so that the furnace can be used for hardening and tempering. The furnace illustrated is suitable for the heat-treatment of carbon and alloy steels

Fig. 45.

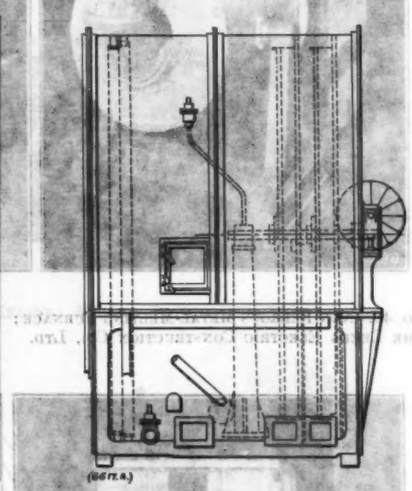


Fig. 46.

Figs. 45 and 46. Air Filter; Messrs. Cleworth, Wheal and Co., Ltd.

up to a maximum working temperature of 1,100 deg. C. A temperature regulation of 25 per cent. is provided. The particular suitability of an electric furnace of this type for much heat-treatment work need not be insisted on. The temperature is under perfect control and the atmosphere of working is entirely free from products of combustion. The articles treated are also heated very evenly, since the bottom, top and sides of the muffles are all uniformly heated by the resistance coils. There is little heat loss by radiation, and with electricity at 1*d.* a unit the cost of current comes out at about 31*s.* per ton of metal heated.

A further important feature of the furnace is illustrated by our two figures, which show the furnace both upright and tilted. The tilting arrangement has been introduced in order that articles being treated may be transferred to the quenching tank in the minimum of time after the desired temperature has been reached. To obtain the best results in heat-treatment work it is important that quenching be carried out at the correct temperature, and with any operation involving the removal of articles from the muffle with tongs it is always possible that some cooling may occur. With this furnace the articles are shot straight into the quenching tank, which is situated below it, by tilting. The doors are provided with spring latches, as shown in Fig. 42, which may be operated after tilting. The time between leaving the furnace and quenching is, of course, minute, so that cooling and surface decarbonisation are eliminated. The makers estimate the time at one thirty-second part of a second.

An electric rivet heater of the type in which the rivet forms part of the secondary circuit of a transformer is illustrated in Fig. 44 subjoined. This is shown by The A.C. Cutting and Welding Company, Limited, of 25-27, Theobald's-road, London, W.C.1. Appliances of this type are, of course, very simple and very convenient in view of the speed with which work can be started at the beginning of a shift and carried on right up to shutting down. They are also suitable for introduction into situations in which the fume afrom an ordinary coke fire would be objectionable, while they have the further advantage that the rivets being heated are directly in view, and are consequently not likely to be burned. Even in the event of rivets being left in too long, one or two rivets only would be spoiled, and not a quantity as may easily occur with a coke fire. The details of the heater are so simple that no extended description is necessary. The transformer is carried at the back of the heater and is wound for either 220 volts or 440 volts A.C. The secondary circuit is, of course, of very low voltage and there is no danger in handling the metal parts constituting this circuit. The machine shown, as will be seen, is arranged for four rivets at a time and the upper contacts are lifted independently by pedals for the insertion of the rivets or to accommodate rivets of different lengths. The appliance is made in various sizes and capacities. While dealing with this rivet heater we should also say that a similar type of appliance is exhibited on the stand of Messrs. J. A. Kinnaird and Co., Limited, of 10, Blythswood-square, Glasgow. This is of the type manufactured by the American Car and Foundry Company, which was illustrated and described in our issue of May 28 last, page 730. As a somewhat allied type of exhibit we may also refer to the "Remca" electric riveting machine, also exhibited by this firm. This apparatus, which is manufactured by the Mada Engineering Company of Liverpool, was fully illustrated and dealt with in our issue of May 7 last, page 625.

An interesting series of exhibits is to be seen on the stand of Messrs. Edmiston, Brown and Co., Limited, of 219, St. Vincent-street, Glasgow. These include a Robey uniflow steam engine and a Robey semi-Diesel marine engine, haulage gears, reversing propellers and other details. From among the material shown we have selected an air filter intended for use in connection with the supply of cooling air to alternators or for general ventilation purposes. This apparatus, which is illustrated in Figs. 45 and 46 annexed, is manufactured by Messrs. Cleworth, Wheal and Co., Limited, of Grange Engineering Works, Castleton, Lancashire. The arrangement consists of two or more rotors built up of fine mesh expanded metal and mounted on a shaft which is slowly rotated by a worm gear

2-8-0 TYPE SUPERHEATER LOCOMOTIVE FOR THE BELGIAN STATE RAILWAYS.

CONSTRUCTED BY MESSRS. SIR W. G. ARMSTRONG, WHITWORTH AND CO., LIMITED, ENGINEERS, SCOTSWOOD.

Fig. 3.

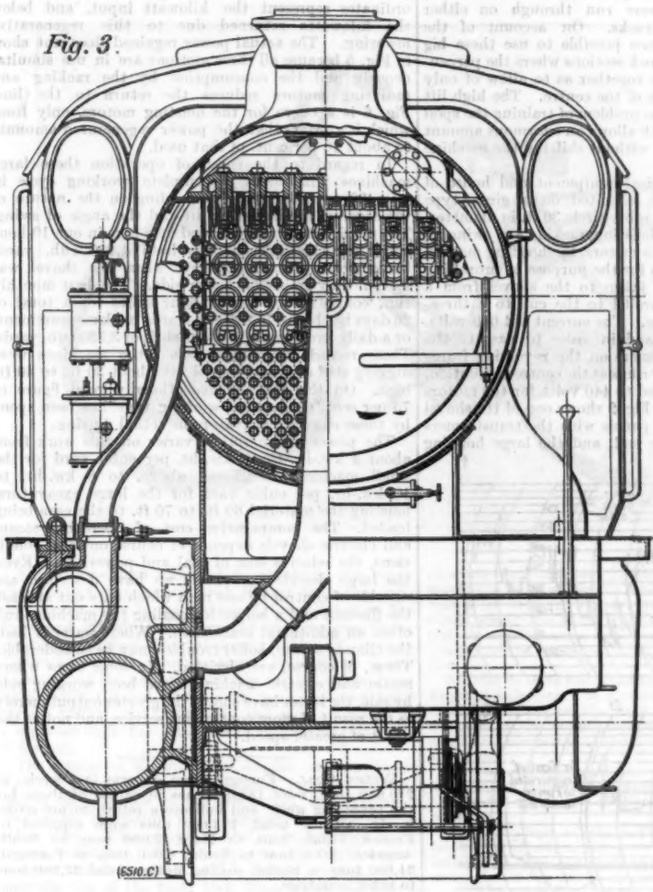
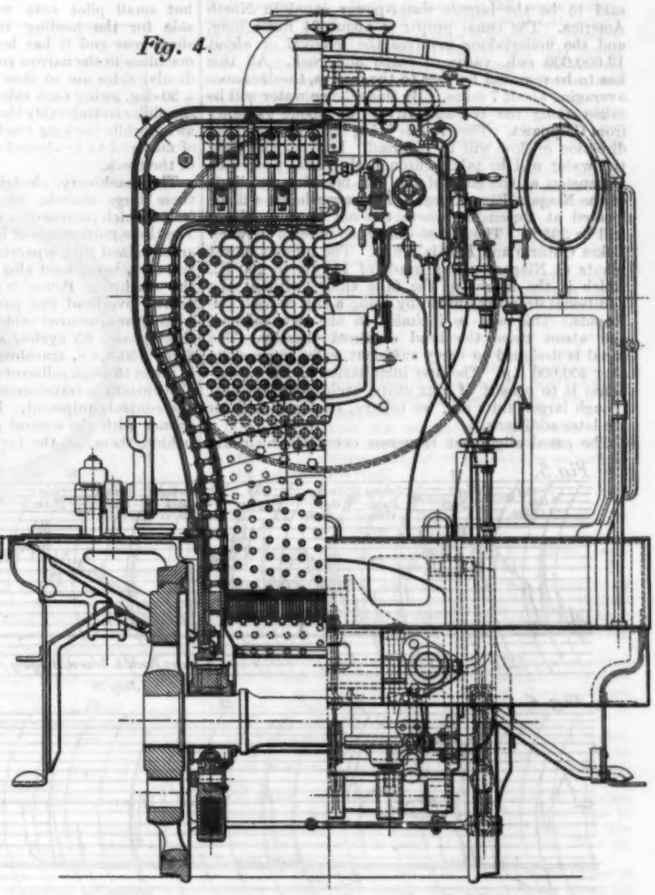


Fig. 4.



which can be seen in Fig. 45, and which can of course be driven by belt, or motor. The lower part of the case containing the rotors forms a tank, and the depth of the water is arranged so that the rotors dip into it to the depth of a few inches. The air which is being cleaned and cooled passes through the machine and the mesh of the expanded metal is set so that the air pursues a tortuous course through the rotors. As the whole surface of the expanded metal is wetted by the water picked up the scrubbing action of the air causes it to be cooled and cleaned. Eliminating baffles at the back of the filter catch loose moisture which is carried by the air current, and cause it to drain back to the tank. The depth of water is maintained by an ordinary ball valve, and the resistance of the plant does not exceed ½ in. water gauge. It will be obvious that the whole arrangement is little likely to give trouble.

Messrs. Cleworth Wheal also construct a desk fan on similar lines to this larger apparatus. The fan is self-contained and simple, and should prove a boon in many situations. The firm also constructs an ingenious water cooler, which is in effect a small self-contained cooling tower. It is made in various sizes for dealing with from 650 gallons to 24,000 gallons an hour. The plant should be of great convenience for use in connection with the jacket water of internal combustion engines and similar services. The arrangement consists of a metal tower with a fan at the top. The body of the tower contains a series of baffle plates, and the water enters at the top, falling on to these baffles and being broken up into a fine spray. The air is drawn in at the bottom and meeting the water spray effectively cools it. The cooled water collects in a tank at the bottom of the tower, and may be tapped away for using again.

(To be continued.)

2-8-0 TYPE SUPERHEATER LOCOMOTIVE FOR THE BELGIAN STATE RAILWAYS.

A LARGE number of 2 8-0 type locomotives have been built recently for the Belgian State Railways by Sir W. G. Armstrong, Whitworth & Co., Limited, at their Scotswood works. The order consisted of 200 locomotives. The design of these engines was worked out by the firm, in collaboration with engineers of the Belgian State Railways. They are of the superheater type, and are very powerful, being fitted with two cylinders, 24 in. in diameter by 28 in. stroke, and having a boiler pressure of 200 lb. per square inch. At 85 per cent. boiler pressure the tractive force works out at 45,820 lb. The ratio of adhesive weight to tractive force is 3 to 1.

In our two-page Plate LXXI with this week's issue of ENGINEERING, we give in Fig. 1 a sectional elevation of this design of engine. In Fig. 2 we give two half plans, one through the frames and axle-boxes and the other above the running-board. In Figs. 3 and 4 above are shown cross-sections, &c. The first consists of a half cross-section taken through the cylinders, and a half front end elevation with part of the smoke-box broken away to show the superheater header and steam pipe. Fig. 4 gives a half section through the fire-box, and a half end elevation at the cab.

The boiler barrel is composed of three rings, 5 ft. 6½ in. in diameter outside the largest ring, and is 14 ft. 9½ in. in length; the length between the tube plates is 14ft. 9in. The fire-box is of the Belpaire type, the inner box being of copper. The latter is 10 ft. 6 in. long and 3 ft. 3¾ in. wide at the bottom. It is designed for and fitted with a grate for burning briquettes, the grate having specially small air spaces for this reason. The back head of the boiler slopes forward and the grate is also sloped considerably. Two forms of superheater have been used in this contract, namely that of Messrs. Marine and Locomotive Superheaters, Limited, and the Robinson pattern.

The engine is designed to pass over curves of 120 metres radius. At the front end a pony truck is provided, centred just at the back of the cylinder box stay. The truck and two front pairs of drivers are equalised in the usual manner. At the trailing end the rear axle is given 30 mm. (1·2 in.) side play in the boxes to either side. The axle loading is moderate, the heaviest load being on the main drivers with 18 tons 17 cwt. The coupling rod pins for the trailing wheels are spherical. We append a table giving the principal dimensions, &c.

Locomotive—	
Cylinders, number	2.
Cylinders, diameter	24 in.
Cylinders, stroke	28 in.
Wheels, diameter	4 ft. 11·84 in.
Wheelbase	28 ft. 1¼ in.
Wheelbase, fixed	12 ft. 1 in.
Boiler, diameter	5 ft. 6½ in.
Boiler, length of barrel	14 ft. 9½ in.
Fire-box, length	10 ft. 6 in.
Fire-box, width	3 ft. 3¾ in.
Tubes, boiler, number	174.
Tubes, boiler, diameter	1·969 in.
Tubes, smoke, number	28.
Tubes, smoke, diameter	5·236 in.
Tubes, length	14 ft. 11¼ in.
Heating surface, boiler tubes ...	1,323·9 sq. ft.
Heating surface, smoke tubes ...	585·2 sq. ft.
Heating surface, fire-box ...	202·5 sq. ft.
Heating surface, total	2,091·6 sq. ft.
Superheating surface	479 sq. ft.
Working pressure	200 lb. sq. in.
Grate area	35·1 sq. ft.
Length (frame)	38 ft. 2 in.
Weight in working order ...	80 tons 4 cwt.
Tender—	
Coal capacity	6 tons 17 cwt.
Water capacity	23 tons 12 cwt.
Weight	52 tons 16 cwt.

Engine and tender, total weight in working order, 133 tons.

(To be continued.)

BRITISH CHAMBER OF COMMERCE FOR ITALY.—The British Chamber of Commerce for Italy has removed from 75, Via Nazionale, Rome, to 238, Via Sicilia, Rome.

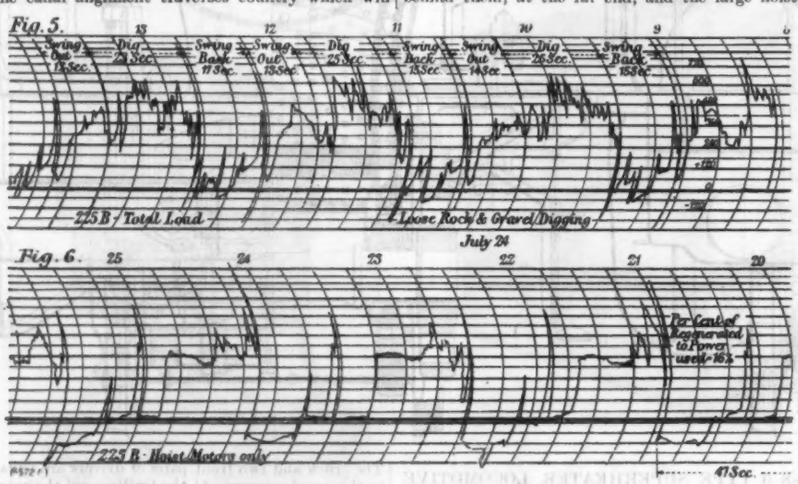
THE CONSTRUCTION OF THE HYDRO-ELECTRIC POWER CANAL AT NIAGARA FALLS.

The Hydro-Electric Power Commission of Ontario, Canada, is engaged on the construction of what is said to be the largest water-power canal in North America. The canal proper is about 8½ miles long, and the undertaking involves the removal of about 19,000,000 cub. yards of earth and rock. All this has to be removed by cars to the dumps, the distances averaging about 7 miles. By this scheme water will be taken along the Welland River for about 4½ miles from Chippawa. The river is being deepened, and its direction of flow will be reversed. Leaving the river the water will be taken through the canal proper to Queenston at the edge of the cliff marking the limit of the Niagara River Gorge. The power-house will be located at Queenston where the net head available will be 305 ft. The actual difference of level between Lakes Ontario and Erie is 326 ft. The present power plants at Niagara utilise heads of 150 ft. to 200 ft., which is the height of the falls alone, without the additional drop obtainable by using a site beyond the Rapids. This will be included in the new scheme, and about twice the head obtained thereby. The canal is designed to carry sufficient water to generate over 400,000 h.p. The first installation at the power-house is to consist of four units, each of 40,000 kw., though larger units are, we believe, contemplated for the later additions.

The canal alignment traverses country which will involve a cut of about 140 ft. at the deepest point. The first 6,250 ft. after the Welland River Section is excavation in earth. Over this portion the canal will have a trapizoidal section with a bottom width of 70 ft. and a side slope of 1½ to 1. This section is followed by a length of 36,252 ft., which is being cut through rock, the width being here 48 ft., with almost vertical sides, of a depth at the highest point through the rock of something like 70 ft., above which the soil is dressed off at a slope of 1½ to 1. The canal is to be concrete lined. There are five changes of direction on the canal, the inside and outside curves at these points being all struck to 300 ft. radius, so that the actual width at these places will be greater than the normal section.

The greater part of the excavating machinery being used for this work is electric, though some steam excavators have been introduced lately in accordance with an accelerated programme, it having been found difficult to secure delivery of further electrical equipment. The plant includes electrically-operated excavators, locomotives, air compressors, &c. The main shovel equipment consists of three large electrically-operated shovels by the Bucyrus Company, whose London offices are at Iddesleigh House, Westminster, S.W. 1. These particular machines weigh about 300 (short) tons, one of them is equipped with a 90-ft. boom and the other two with 80-ft. booms, all with shovels capable of taking 8 cub. yards of earth or 6 cub. yards of rock. There are, further, several electric railroad-type shovels, and eighteen 50-ton electric locomotives. The rolling-stock consists of over one hundred and fifty 20-yard air dump cars. Our illustrations, Figs. 1 to 4, page 740, will give a good idea of the larger machines, and the conditions under which they are working. From the foregoing remarks on the canal it will be gathered that the excavation work requires high lifts, the loading tracks to the spoil dumps being frequently 60 ft. to 70 ft. above the rail level of the excavating machine. Fig. 1 shows one of these shovels at a deep point of the cut, the whole depth being taken at one cut. This view also gives an idea of the reach of the shovel, and the ease with which it can dump into cars at high level, the operation being again depicted in Fig. 3. Fig. 4 gives an idea of the cut itself. In places this cut was 80 ft., but small pilot cuts were run through on either side for the loading trucks. On account of the short rear end it has been possible to use these big machines in the narrow rock sections where the perpendicular sides are so close together as to allow of only a 30-deg. swing each side of the centre. The high lift simplifies considerably the problem of training the spoil away, while the long reach allows an enormous amount of material to be cleared without shifting the machine or the track.

The machinery, electrical equipment and house of these large shovels, are mounted on a girder-type frame which rotates on a roller circle 30 ft. in diameter. The three movements of hoisting, racking and swinging are obtained with separate motors, the hoisting motors, however, being used also for the purpose of propelling the machine. Power is taken to the shovel from a nearby overhead line parallel to the cut, to a three-conductor armoured cable. The current is 4,000 volts, three-phase, 25 cycles, and in order to pass to the three 150-k.v.a. transformers on the revolving frame is taken through collector rings at the centre of rotation. The current is transformed to 440 volts for the motors and control equipment. Fig. 2 shows one of the shovel frames with the control panels with the transformers behind them, at the far end, and the large hoisting drum and motors and the swinging motor towards the nearer end.



The hoisting unit consists of two motors of 225 h.p., intermittent rating, driving the 54-in. winding drum, by double helical gears and an intermediate shaft. The cable is 2 in. By means of a band clutch operated by compressed air from a motor-driven compressor, the motors, intermediate shaft, and main hoist gear can be disconnected from the drum. An air operated band brake on the drum shaft is used for holding the shovel at the desired height while swinging. Two hoist motors are used as the particular type suitable for rough shovel work has not been developed in the larger sizes, and also for the reason that the flywheel effect of two small motors is less than it would be for one large one of this character.

The swing, or radiusing motor is 140 h.p., intermittent rating, and is geared through reduction gearing to a pinion meshing with the rack on the stationary base. A slipping clutch on one of the intermediate shafts relieves overstrains due to rough handling, as in the steam shovel. The thrust or racking motor is also of 140 h.p., and this gear is also fitted with a slipping clutch to protect it. An air operated band brake automatically controlled relieves the racking motor when it is desired to hold the shovel at a certain radius. The whole machine is moved by the hoisting motors through shafts and gears passing to the lower frame through the centre, and geared to all the 16 wheels of the machine.

The control equipment is of the magnetic type, equipped with automatic gear to limit the accelerating peak load, and also on the hoist motor to limit overload while digging, by the automatic insertion of resistance in the motor circuit. This is effected without interrupting the pull on the bucket. The bucket is arranged for regenerative lowering, that is to say, after dumping the load the motor is reversed and the falling shovel overhauls the motors, driving them above the synchronous speed so that energy is returned to the line. Not only does this reduce the total current consumption, but it also results in a reduction of brake wear, and a considerable simplification of control and operation. A load curve taken with a recording meter on one of these shovels is shown in Figs. 5 and 6 herewith. A zero line is shown in both figures above which the ordinates represent the kilowatt input, and below the kilowatts returned due to this regenerative lowering. The actual power regained does not show in Fig. 5 because all three motions are in use simultaneously and the consumption by the racking and radiusing motors reduces the return to the line. Fig. 6 is a curve for the hoisting motors, only from which it appears that the power regenerated amounts to about 16 per cent. of that used.

In regard to the speed of operation these large machines will make a complete working cycle in from 30 to 50 seconds, depending on the nature of the digging, the height of lift and the angle of swing. The maximum yardage loaded into cars in one 10-hour shift, on this project, has been 4,930 cub. yards bank measurement, obtained when the shovel was served with trains on either side. The best monthly run, consisting of two 10-hour shifts for a total of 26 days has been 175,800 cub. yards bank measurement, or a daily average per 10-hour shift of 3,380 cub. yards. These records were made when the machines were digging stiff clay against a bank about 30 ft. to 40 ft. high. On this job the exceptionally good figure of 75 per cent. of the total working time has been spent by these electric excavators in actual digging.

The power consumption varies on this work from about 4 kw.-hr. to 10 kw.-hr. per cubic yard for the small machines mentioned above, to 8 kw.-hr. to 10 kw.-hr. per cubic yard for the large excavators, hoisting the material 60 ft. to 70 ft. to the cars being loaded. The comparative cost of operating steam and electric shovels depends of course on local conditions, the relative cost of coal and power, &c. Even the large electric excavators we have described are capable of control by one man which cuts out at least the fireman and a helper for coaling the machine, and often an additional cranesman. Where water is bad, the climate severe, boiler troubles may be considerable. These, of course, are obviated. In some cases where steam and electric machines have been working side by side, the latter have shown the greater output merely as the result of more continuous service, and not as the result of greater speed.

Welsh Coal.—Foreign cargo exports last week, at 270,000 tons, were 182,000 tons in excess of those for the preceding week, and indicate a return to pre-strike levels. Of the total, 174,000 tons were supplied to France, 39,000 tons to Italy, 2,000 tons to South America, 5,000 tons to Spain, 6,000 tons to Portugal, 21,000 tons to British coaling stations, and 22,000 tons to other countries.

The Cammell Concrete Block Machine.—A demonstration in the manufacture of hollow concrete blocks was given last Tuesday, at 83, Forest-street, Forest Gate, with the Cammell concrete block press. The blocks made were of 5 to 1 concrete (3 shingle, 2 sand and 1 cement), measuring 12 in. by 8 in. and 6 in. deep, weighing 28 lb. in the dry state. The press gives a pressure up to 40 tons, which operates throughout the mass of the concrete forming the block, and so consolidates the material that there is practically no shrinkage by drying in the open air. A feature of the mould is the provision made for releasing its four sides after the block has been pressed, thus enabling the easy withdrawal of the latter. The concrete blocks turned out by the machine are said to be suitable for all classes of structures, from cottage building to the heaviest engineering work, and it is claimed that they can be "built in" within 24 hours of leaving the press. Crushing tests made of Cammell cored blocks, 37 days old, and of the above composition, showed a crushing strength of 84 tons per square foot; the actual load taken to break the block being 57·02 tons.

Personal.—Messrs. Thomas Tilling, Limited, state that their registered office is now 20, Victoria-street, Westminster, S.W. 1. Telephone: Victoria 9756. Telegrams: Tilling, Vic, London.—Mr. John Bentley, manager of the switchgear department of Messrs. Laurence, Scott and Co., Limited, Norwich, is leaving to take up an appointment with Messrs. J. H. Wilson and Co., Limited, Birkenhead.—We are informed that the Harbour Improvement and Mechanical Engineering Company, Limited, has been formed to develop interests previously controlled by Mr. B. J. Allison, 53, New Broad-street, E.C. 2, and is interested in contracting to supply and deliver dredgers, tugs and similar floating harbour plant, and also to supply and erect cranes of all types for harbour and dock purposes, &c. The company has made arrangements with Wilton's Engineering and Slipway Company, Rotterdam, this placing them in a very favourable position, for dealing with the shipbuilding side of the business. It has also obtained the sole concession of the crane designs of the Figee Works, Haarlem, which will enable the company to supply all types of cranes and other hoisting machinery to any part of the world. All inquiries should be addressed to the Company, at their offices, 53, New Broad-street, London, E.C. 2.

THE CYCLAID MOTOR BICYCLE.

CONSTRUCTED BY THE SHEPPEE MOTOR COMPANY, LTD., ENGINEERS, YORK.

AMONG machines intended to cater for the buyer who wants a motor very much lighter than the ordinary motor-cycle is the "Cyclaid," exhibited at the Cycle and Motor Cycle Show by the Sheppee Motor Company, Limited, Thomas-street, York. We give an illustration of this machine above, from which it will be seen that the motor is entirely carried on the front forks, while the rest of the cycle is an ordinary pedal cycle. In fact, the front forks and motor are sold as a separate unit for attachment to an ordinary cycle if desired.

The motor is a two-stroke engine, with cylinder 2 in. by 2 in. (50 mm. by 50 mm.), rated at 1¼ h.p., placed on one side of the front hub, and having a crankshaft extending right through the hub to the other side. This allows of the main bearings being placed well apart. On the opposite side to the engine a chain wheel is placed which drives a countershaft near the top of the front fork, from which the hub is driven by another chain. The total reduction between the engine and wheel is 11 to 1. This gives a maximum speed of 25 miles an hour at 2,500 revolutions. The countershaft runs on Hoffman ball bearings, and has on it a plate clutch with cork inserts, giving a free engine when desired. The petrol and oil tanks are placed on the front forks, which are spring mounted. Lubrication is automatic, by a small pump driven off the hub by a worm and wheel. The weight is stated to be 38 lb., in addition to the weight of the ordinary cycle.

It will be seen that this fitting has the merit of not placing any additional weight on the frame of the cycle while the engine is away from the rider's clothes, and therefore special garments should not be necessary for riding.

NOTCHED-BAR IMPACT TESTS.*

THE CHARACTERISTICS OF NOTCHED-BAR IMPACT TESTS.

By THOMAS ERNEST STANTON, C.B.E., D.Sc., F.R.S., M.Inst.C.E. and REGINALD GEORGE CYRIL BATSON, Assoc.M.Inst.C.E.

AFTER giving a brief account of the early work on the subject, together with the progress of the standardisation of the notched-bar test in Europe, the paper points out that, although the value of the test in discriminating between correctly and incorrectly heat-treated material has long been fully recognised, the chief objections to immediate standardisation in Britain were :—

(1) The desirability of obtaining a more definite interpretation of the test, to determine whether the relative results obtained had any relation to the relative impact strength of the materials when in practical use.

(2) The variability in the results of individual tests.

A research on these lines was commenced at the National Physical Laboratory in 1915, with the aid of funds granted by the Institution, and the construction of the necessary apparatus was put in hand. Before, however, the tests could be commenced, it was decided by the Panel of the British Engineering Standards Association, which dealt with notched-bar tests in 1916, that the programme should be suspended in order to investigate the relative superiority of the different forms of notch commonly used for 10 mm. by 10 mm. notch-bar specimens in this country and on the Continent. The reason for this action was that, owing to the adoption of the test by the Ministry of Munitions as an acceptance test in specifications, the standardisation of a notch which could be easily machined in alloy steels was imperative.

A series of tests was accordingly made at the National Physical Laboratory to investigate :

(*a*) The effect on the work of fracture and the consistency of the results obtained of a variation in the angle and sharpness of the notch in 10 mm. by 10 mm. specimens.

(*b*) The sensitivity of the various types of V-notch in revealing faulty heat treatment.

Broadly, the results of the tests may be summed up as follows :

(1) The shape of the bottom of the notch has an important effect on the work of fracture, which has its least value when the angle at the bottom of the notch is as nearly zero as can be obtained.

(2) The variations in the results of individual tests are not inherent in the method of test, but are due to a want of homogeneity in the material. This conclusion was also confirmed about the same time by M. Charpy, who found that by taking extraordinary care in heat treatment to ensure homogeneity of structure in the material tested, it is possible to obtain a degree of uniformity in the results of the notched-bar tests which is higher than any other mechanical test to which the material can be subjected.

(3) The form of 10 mm. by 10 mm. specimen developed by the Aeronautical Inspection Directorate during war, which has a 45-deg. notch having a radius of 0·25 mm. at the bottom, is equally as effective in the detection of faulty heat treatment as the Charpy specimen. It is not, of course, suggested that these are the only two specimens which are effective in the detection of heat treatment, as, for instance, it is well known that the Frémont specimen is quite satisfactory in this respect.

Dimensional Effect on Notched-Bar Testing.—After the conclusion of the standardisation work on the 10 mm. by 10 mm. specimen, the original investigation was taken up again.

In order to obtain a clearer interpretation of the test, it was decided that a careful study of the dimensional effect in notched-bar impact tests should be made. For this purpose, five geometrically similar test-pieces, whose cross-sectional dimensions were 5 mm. by 5 mm., 10 mm. by 10 mm., 15 mm. by 15 mm., 30 mm. by 30 mm., and 63 mm. by 63 mm., were selected, and five geometrically similar sets of strikers and knife edges were fitted to five testing machines in which the masses of the striking hammers and anvils carrying the specimens were roughly proportional to the masses of the respective specimens.

Complete series of tests were made on a low-carbon steel, a high-carbon steel and Yorkshire iron. Broadly stated, the results of the tests on these materials showed that it was quite impossible to predict which material would be the safest to use in a structure subject to vibration and shock except by experiments on the full scale. It must be realised, of course, that the materials in question were widely different as regards mechanical properties, and the comparison obtained was an extreme one. Nevertheless, the conclusion seems unavoidable that the value of the impact test, as at present understood, lies not in discriminating between the impact resistances of different materials, but as a means of ensuring that the impact strength of any given material is at its highest.

Effect on the Work of Fracture of the Striking Velocity of the Hammer.—No definite evidence that the rapidity of the fracture had any appreciable effect on the work done in fracture had been noted by previous experimenters. In their experiments, however, the value of the striking velocity of the hammer had not exceeded about 20 ft. per second. Owing to the facts that some experiments carried out at the National Physical Laboratory at 28 ft. per second gave indications of a possible velocity effect, and that Sir Robert Hadfield had also found marked effects due to velocity of striking in the case of embrittled steels, it was decided to make tests at still higher velocities.

The 10 mm. by 10 mm. testing machine was therefore fitted with arrangement to give velocities up to 43 ft. per second, and tests have been carried out on various materials at striking velocities up to this value.

It was found that the speed effect depended on the nature of the material tested, and when it existed did not necessarily imply a reduction of the energy for fracture as the speed increased.

In those materials which had a marked velocity effect, this effect was only definite at velocities above about 16 ft. to 20 ft. per second.

It was thought that the work of fracture might contain a term depending on the time of fracture of the test-piece. Tests were, therefore, made to determine the time of fracture as well as the value of the energy of fracture. The specimen was placed in the circuit of one of the wires of an Einthoven galvanometer, and the reduction in resistance of the specimen, due to the reduction of its effective conducting section during fracture, was recorded on the photographic trace of the instrument, which was provided with a time scale.

It appeared from the results that there was some indication that the energy of fracture was dependent on the rate of deformation of the specimen as well as on the deformation itself.

* Abstracts of three papers read before the Institution of Civil Engineers on Tuesday, November 30, 1920.

NOTES ON THE SINGLE-BLOW IMPACT TEST ON NOTCHED BARS.

By RICHARD HENRY GREAVES, M.B.E., M.Sc., and HAROLD MOORE, O.B.E., B.Sc.

Experimental work on notched-bar test-pieces from oil-hardened and tempered carbon, nickel and nickel-chromium steel forgings broken in the Guillery, Charpy and 120-ft.-lb. Izod machine, has led to the following conclusions :—

(1) The 0·25 mm. radius V-notch test-piece specified by the British Engineering Standards Association appears to be the most satisfactory as regards discrimination between tough and brittle material, uniformity of results, and ease of machining.

(2) Variations in the radius of the notch below 0·25 mm. result in differences in impact figure, which do not on an average exceed 2 ft.-lb. in the case of the steels used.

(3) Other conditions remaining the same, an increase in radius of the notch is accompanied by an increase in energy absorbed (from E_1 to E_2) and for steels of the same type over a wide range of impact figure, $E_2 = E_1$ + a constant.

(4) The regularity of the results for certain types of steel is sufficient to enable the impact figure given by one of the forms of notch and machine used to be deduced approximately from that given by another form of notch and machine.

The significance of the test is briefly discussed. It is regarded as a test of capacity for plastic yielding without rupture under localised stress. Reference is made to the practical value of the test in eliminating from material otherwise suitable that type which is most liable to fail in conditions of service where sudden localised stresses are unavoidable or may accidentally arise.

THE EFFECT OF OVERSTRAIN ON THE IMPACT FIGURE OF STEEL.

By RICHARD MORGAN JONES, M.Sc., and RICHARD HENRY GREAVES, M.B.E., M.Sc.

Notched-bar impact tests were made under standard conditions in the 120-ft.-lb. Izod machine on heat-treated carbon and nickel-chromium steels which had been subjected to varying degrees of overstrain.

In each case the impact figure was progressively reduced by increasing amounts of overstrain, and was still further lowered by low-temperature annealing—a treatment which also results in recovery of the elastic limit and a slight increase in hardness. The impact figure of very brittle nickel-chromium steel (below 8 ft.-lb.) is not further lowered by overstrain.

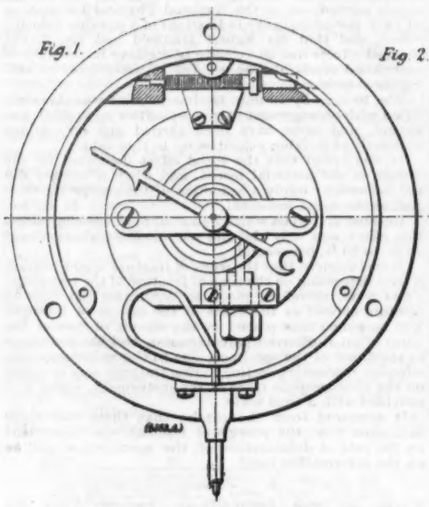
The results illustrate the effect on the impact figure which would be produced by cold work of any kind, *e.g.*, hammering, rolling or drawing.

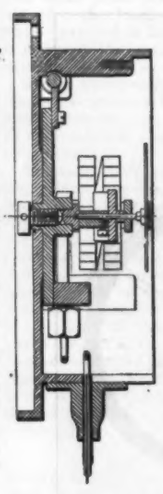
BOTTLE MANUFACTURE IN SOUTH AFRICA.—We read in the *South Africa Mining and Engineering Journal*, that a bottle manufacturing industry, on a scale sufficient to meet local requirements for all classes of bottles, will be in operation in the Union within the next twelve months.

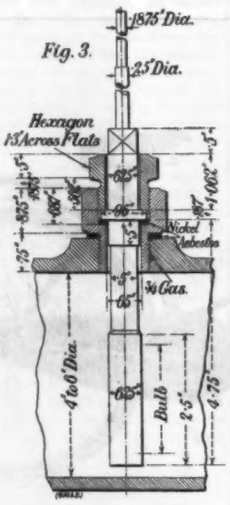
THE BRITISH SILK RESEARCH ASSOCIATION.—The Secretary of the Department of Scientific and Industrial Research announces that a licence has been issued by the Board of Trade to the British Silk Research Association which has been approved by the department as complying with the conditions laid down in the Government scheme for the encouragement of industrial research. The secretary of this association is Mr. A. B. Ball, Silk Association of Great Britain and Ireland, Inc., Kingsway House, Kingsway, London, W.C.

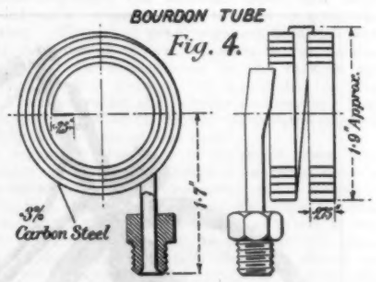
DISTANCE-READING THERMOMETER.

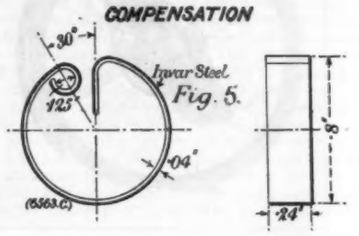
CONSTRUCTED BY MESSRS. NEGRETTI AND ZAMBRA, LONDON.

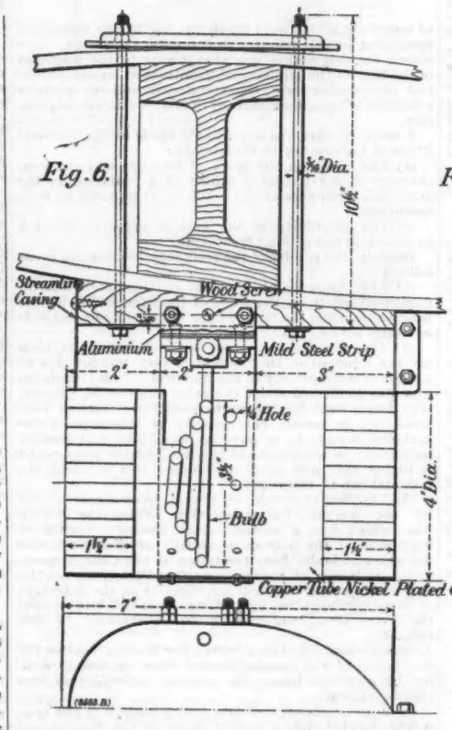












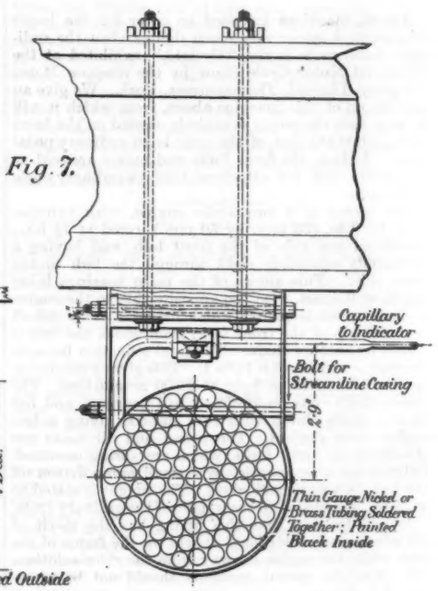


Fig. 7.
Capillary to Indicator
Bolt for Streamline Casing
2·9"
Thin Gauge Nickel or Brass Tubing Soldered Together: Painted Black Inside

In its broad lines a distance reading, or transmitting, thermometer need not differ from the ordinary mercury or spirit thermometer with which everyone is familiar. In its details, however, much consideration of the conditions which have to be met is necessary if accuracy is to be secured. Such thermometers may be either of the vapour pressure or liquid expansion types, but each has its own special difficulties and liabilities to error. The vapour-pressure type in general gives a very uneven scale, while variations in barometric pressure and the relative heights of the bulb and the indicator introduce sources of error. The liquid-expansion type is probably the simpler, but in this case, unless proper steps are taken to compensate for it, serious error may arise owing to differences in temperature between the bulb and the indicator and the tube connecting it thereto.

In practice it is seldom that the temperature of the connecting tube will be constant or will bear any constant relation to the temperature of the bulb, and some method of compensating for the temperature of the tube is essential if the instrument is to have any accuracy. This compensation is sometimes arranged for by running a second tube parallel to the main tube and controlling the position of the scale of the indicating instrument by the expansion or contraction of the liquid in the second tube. With this arrangement the effects of tube temperature balance out, since any error of position of the indicator due to the temperature of the connecting tube is compensated for by a corresponding "correcting error" in the position of the scale. This arrangement is, however, a comparatively complicated one, the indicating instrument contains two moving parts instead of one, and various connecting links and a number of pivots are necessary.

Another method of correction is to introduce a bimetallic compensator in the indicating instrument to control the position of the scale. This again somewhat complicates the instrument, but its obvious weakness lies in the fact that for it to operate accurately the connecting tube must always remain at the same temperature as the indicating instrument, which in many cases will be far from the case. The difficulty of variation in the temperature of the connecting tube may also be to some extent met by making the tube of such small capacity that its total volume is negligible compared with the volume of the bulb. This method is clearly only an approximate one, and it any case introduces practical difficulties if the connecting tube is required to be of any considerable length. An entirely different and very neat method of compensating for the temperature of the connecting, or capillary, tube has recently been introduced by Messrs. Negretti and Zambra, of 38, Holborn Viaduct, London, E.C. 1. In addition to the new form of capillary tube the appliance also includes a new form of indicating Bourdon gauge, in which all connecting links and multiplying mechanism have been eliminated, and the complete instrument is one of great accuracy and at the same time of great simplicity.

The method by which errors due to capillary tube temperature are eliminated in the Negretti and Zambra instrument is a very neat one, and has the effect that each unit length of the capillary compensates for itself and there is no outside, or overall, effect at all due to the temperature of the connection. Various parts of the capillary may be at widely different temperatures without the accuracy of the thermometer being affected. This effect is achieved by making the capillary of material of high expansion and running throughout its length a wire of a material of low expansion. The diameter of the wire is something less than the bore of the tube, and it is made in lengths so that it can slide in the tube when temperature changes occur. The space not occupied by the wire contains the working fluid, and the volume of the wire and fluid and the capacity of the tube are so calculated that for a given change in temperature the change in the volume of the fluid is the same as the change in the space it can occupy, so that no fluid is expelled into the indicator to move the index. The tube containing the wire is quite flexible and can be bent several times at right angles without breaking or blocking the capillary.

The new form of indicating instrument which is used in conjunction with this patented form of capillary is of the Bourdon type, and is illustrated in Figs. 1 and 2, annexed. These figures show the connection of the tube to the instrument, while Fig. 3 shows the type of bulb which is used and indicates the diameter of the capillary and of the contained wire. The Bourdon gauge is of great interest since, as we have already mentioned, all multiplying gears and, consequently, all gears and levers have been eliminated. This eliminates all frictional and backlash errors, and even when the instrument is fixed in a position in which there is no vibration it is not necessary to tap it to bring it to the correct reading. The construction is a simple one and consists in connecting the inner end of the Bourdon tube directly on to the pointer. In order to allow of this and to obtain sufficient movement to give an open scale, the tube is made to comprise several coils in two layers, as shown in Fig. 4. There is only one pair of pivots in the instrument, those carrying the pointer and the inner end of the Bourdon tube.

It will be evident from what we have already said that the compensating arrangement of the capillary

ROTOR BALANCING MACHINE.

CONSTRUCTED BY THE VIBRATION SPECIALTY COMPANY, PHILADELPHIA, PA., U.S.A.

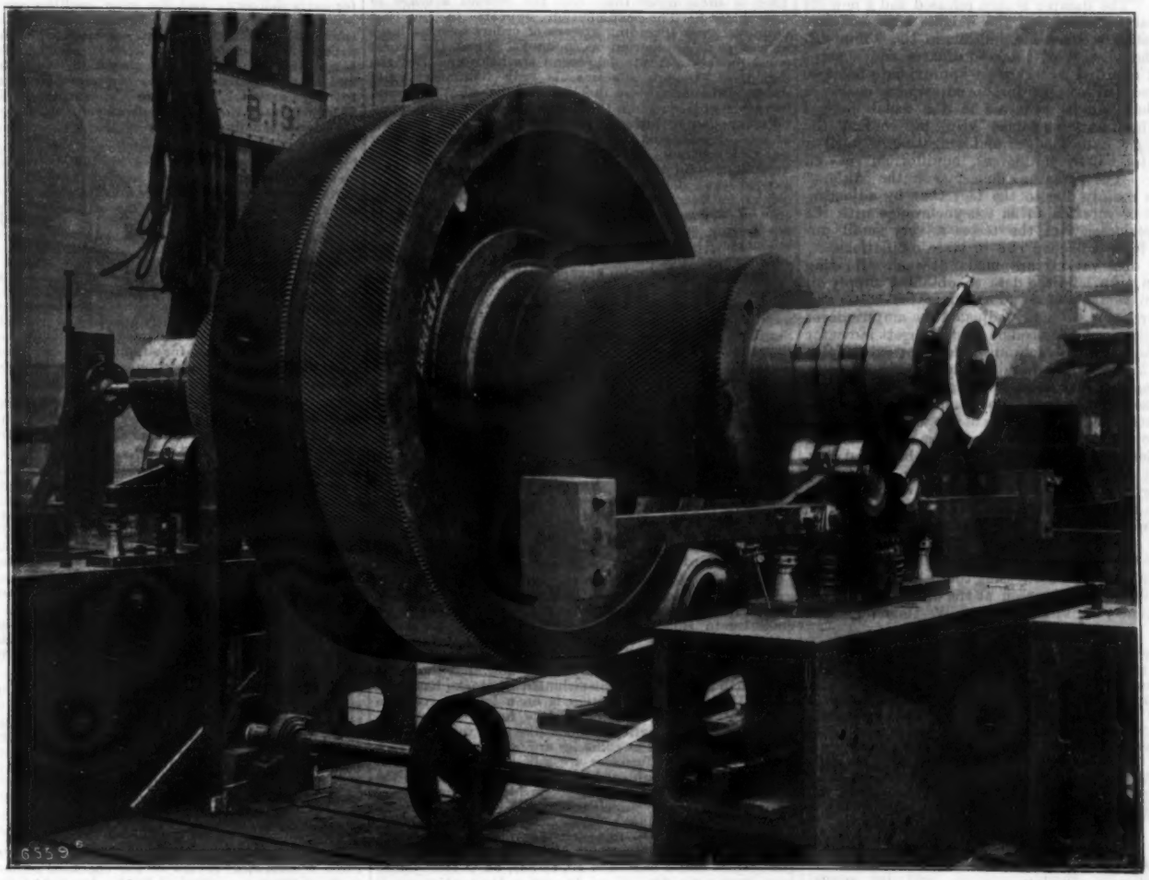


FIG. 1.

tube does not compensate for variation in temperature of the indicating instrument itself. This is independently arranged for by a bimetallic strip, illustrated in Fig. 5. Owing to the simplicity of the instrument this compensation becomes of a very simple nature.

There is another possible source of error in connections with instruments of this kind to which we have not yet referred. This is that due to the height of the bulb with respect to the indicator. For short lengths this error is negligible, but if the bulb is fixed 50 ft. above the indicator a small error becomes apparent. This is very simply eliminated in the Negretti and Zambra instrument by adjusting the zero. This is carried out by the adjusting screw which can be seen at the top of the gauge in Figs. 1 and 2. The effect of rotating this screw is to rotate the scale as a whole around the pointer centre. This very simple arrangement is allowable since the Bourdon tube is so proportioned that the scale is an absolutely uniform one.

Our remaining illustrations, Figs. 6 and 7, on page 736, do not require much comment. They show a special form of bulb and its mounting for a thermometer of this type mounted on an aeroplane for obtaining the air temperature. A number of these have been manufactured by Messrs. Negretti and Zambra for the Air Board. The arrangement will be clear from the figures and it will be seen that the bulb is mounted in a cylindrical casing with nests of open-ended tubes at each end, so that it is subjected to a steady air flow.

ROTOR BALANCING MACHINE.

WE illustrate on this page a machine devised by Mr. N. W. Akimoff for testing both the static and the dynamic balance of high-speed rotors. The machine is shown in Fig. 1 as installed at the works of Messrs. William Beardmore and Co., with a 14-ton gear mounted upon it, but patterns are also made suitable for testing and adjusting the balance of motor-car crankshafts and other light rotors. In general a rotor of any

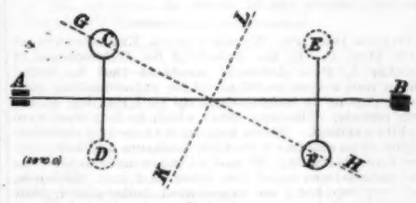


FIG. 2.

kind may be out of balance in two ways as will be clear from a consideration of Fig. 2. In this diagram A B represents an ideally weightless shaft having mounted on it four equal weights, C, D, E and F, symmetrically arranged as indicated. The centre of gravity of the system lies, therefore, in the line A B, and the shaft thus loaded will be in perfect balance. If the weights E and D be removed, however, the system though statically balanced will vibrate badly if set in motion, as although the opposing centrifugal forces due to the two remaining weights C and D are equal, they do not act in the same straight line, and there is thus a centrifugal moment which may give rise to very serious vibrations. In short, the system, though statically balanced, is still seriously out of balance dynamically, since dynamic balance can only be secured when both the resultant centrifugal forces and the centrifugal moments are zero. Thus when a system is balanced dynamically it must also be balanced statically, and this is the principle on which the Akimoff machine is designed. Its construction is shown in Fig. 1, where it will be seen that the ends of the rotor under test are carried on rollers, which for their own part run on ball bearings so as to reduce friction to a minimum. The casting on which these rollers are mounted is supported at its centre on a strip of thin steel plate which serves as a substitute for a knife edge, and by its flexibility allows the casting freedom to move horizontally to and fro in a direction at right angles to the axis of the rotor under test. The weight of the latter is, however, for the most part carried on two helical springs clearly visible in the photograph, and there are in addition two screw jacks, which can at will be made rigid. Arms bolted to the casting carry sliding weights which can be clamped where desired, and serve to vary the natural periodicity of the whole system of support. On the end of the shaft of the rotor under test is fixed a clamp provided with screwed arms, on which travel the balance adjusting weights. These arms are, moreover, hollow and can if necessary have additional weights placed inside them, when the lack of balance is too large to be corrected by the external weights supplied.

In making a test, the periodicity of the balance tester is adjusted so that it will synchronise with a speed of rotation somewhat below the maximum at which it is intended to run the rotor during the test. The rotor is belted to a counter shaft driven by a 7 h.p. variable-speed motor, and, in commencing operations, is run gradually up to speed. The screw jacks belonging to the Akimoff bearing nearest to the driven end of the rotor and tightened up rendering this bearing rigid whilst observations are made at the free Akimoff bearing. If, as is usual with an untested rotor, the out of balance is considerable, the vibrations of the support are damped by screwing down a damping plate, which can be seen in Fig. 1, at the centre of the apparatus. The amplitude of the oscillations is observed by means of a Starrett indicator, which is to be seen at the near end of the machine in Fig. 1.

Having by the damper reduced the oscillations to a figure that can easily be read the correcting weights on the clamp are adjusted to a true position and the result recorded. The clamp is then shifted through 90 deg., and the observations repeated. Similar observations are made with the clamp at

180 deg. and 270 deg. with its initial position. A comparison of the amplitude of oscillation observed with these four different settings indicates approximately the angle at which the clamp must be fixed for the oscillation to be a minimum, and the actual angle is then readily found and the clamp set in this position. The damper is then released and a new set of observations made, and the weights adjusted until the oscillation becomes insignificant in these four different conditions gives the co-ordinates and amount of weight required to secure an approximate balance.

The precision attained in this adjustment is always greater than can be achieved in the usual method of attaining static balance, viz., by rolling the rotor along "knife" edges and weighting it until it appears to be in indifferent equilibrium in all positions. The greater delicacy of the Akimoff method is mainly due to the fact that by adjusting the speed of rotation so as to synchronise with the natural periodicity of the tester a very small unbalanced force will give rise to large oscillations.

Similar observations are made at each vibrating bearing in turn, and the data so obtained supply all the information necessary to calculate the static and dynamic errors. As finally adjusted the amplitude of the oscillations of the needle of the Starrett indicator even at the speed of synchronism does not exceed plus or minus 5 mils. In general the total time taken to secure practically perfect balance of a heavy rotor does not exceed six hours as a maximum, and at a recent demonstration of the apparatus at the works of Messrs. Beardmore with a 1½ ton Brown Curtis rotor, the test was completed in 2½ hours. It should be stated that to prevent axial motion of a rotor under test a ball-thrust bearing is clamped to one end of it, and in making a test the drive is always transmitted to the end of the rotor opposite to that supported by the balancer.

A small machine constructed on the same principle as that we have illustrated, but differing considerably in detail, and suitable for testing the balance of motor-car crankshafts, can be seen at the offices of Captain J. E. Mortimer, 34, Victoria-street, Westminster.

Institution of Mechanical Engineers: Errata.—We regret that two errors crept into our report on the recent discussion at the Institution of Mechanical Engineers on Captain Arthur's paper on the "Sterilisation of Water by Chlorine Gas." Mr. W. Paterson, in speaking of Major Nesfield's early work stated that the latter had used sodium sulphite for dechlorination; our report mentioned sodium phosphate by mistake. In connection with the apparatus exhibited and described by Mr. Paterson the isolation of the mechanism from the water is effected by a column of water disinfected (not "infected") by the chlorine gas.

Association of German Iron Masters.—When the Verein deutscher Eisenhüttenleute held its annual meeting at Düsseldorf last month, it was announced that the number of members had decreased from 6,443 in May, 1919, to 6,220 last May. Among the many well-known deceased members were Fritz W. Lürmann, H. Macco, W. Ugé and E. Leber, the last-mentioned having been on the staff of the journal of the *Verein, Stahl und Eisen*. A new publication of the Verein, "Industrie und Technik," is now published in English under the title "Engineering Progress," and in Spanish as "El Progresso della Ingeneria." Dr. A. Guttmann's book (now out of print), "Application of Blast-Furnace Slag in Building Construction," was also published by the Verein, which is preparing a new edition. The various technical research committees on Blast-Furnace Slag Utilisation, Rolling Mills, Materials Testing, Ores, Coking, Foundries, had also issued *Mitteilungen*. The branches in Upper Silesia and in the Saar district, which had had to abandon their meetings, were hoping to resume their regular activity.

Magnetic Search for Iron Ore.—Though the connection between the irregularity of the values of terrestrial magnetism and the occurrence of magnetic ores in the ground have been investigated for more than half a century, any noteworthy utilisation of these determinations in the search for iron ores was not made till comparatively recently. In northern Sweden, in particular, Carlheim-Gyllenskiöld greatly assisted the mining operations for magnetite by his magnetic measurements. Eotvös then found in Hungary that even feebly magnetic ores could be traced with highly-sensitive instruments. In the course of his magnetic survey of this country Professor Ernest Wilson (see Engineering March 19, 1920, page 316), devised instruments which greatly facilitated the tests of very faintly magnetic minerals. The research now carried on in Bavaria by A. Gallus, J. Königsberger and R. Griesser is conducted with the aid of simple instruments, measuring the horizontal intensity within ± 10 γ and the declination with ± 2 minutes of arc. With such instruments they found iron near Amberg and near Königstein, this ore being brown ironstone. In the Hartz district they discovered iron clay at depths of 50 m.; in the Sieger district (near the Rhine) spathic iron ore was detected at similar depths, but they failed to trace iron ores embedded at depths of 100 m. in non-magnetic minerals and quartz. Details of the search, which requires the co-operation of geologists and physicists, are to be published in the *Zeitschrift für Geologie*.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—Statements of declining activity in the heavy engineering trades find small expression in actual unemployment. The total on the books of the Sheffield Labour Exchange does not exceed 5,000. This is little more than half the normal average of unemployed. The explanation appears to be that employers are spreading arrears of orders over as large an area of production as possible. Thus the worst consequences of trade depression are held off. But the expedient, though effective, is only temporary, and unless order books are quickly replenished it is feared in responsible quarters that the large firms will shortly be compelled to release whole departments of workers, and set down plant for an indefinite period. Cancellations of contracts continue in the heavy sections. As a result, rolling mills are affording only four days' work a week, but dare not delay production on unfinished orders for fear buyers may suddenly decide that the cost of the work is prohibitive. Engineering masters are having small success in the competition for new business. Owing largely to the high cost of fuel and heavy wages bills, the lowest quotations that can possibly be given are declared by buyers, both home and foreign, to be excessive. There is little improvement in crucible or electric steels. Several furnaces are out of commission, and will not be restarted until after Christmas. Similarly, output of special steels is at a low level. Ferro-alloys are a drug on the market. Purchases are limited to immediate requirements. Most of the tool trades continue to enjoy a high level of prosperity. The heavy run on garden tools, agricultural implement parts, pincers and pliers, and joiners' tools, has not yet exhausted itself. Developments are looked for as regards semi-finished materials. Local producers of basic steel are being badly undersold by foreign makers. There is little demand for Sheffield basic when Belgian and American basic can be brought for upwards of 1*l.* per ton. Sheffield has contributed substantially in the way of materials, machinery and fittings to the construction of the newly-launched steamship "Samaria," built by Messrs. Cammell Laird and Co., Limited, for the Cunard Company.

South Yorkshire Coal Trade.—Conditions throughout are nearer the normal than for a considerable time past. A sustained improvement is reported in output from collieries in this area. Supplies are ample for most requirements. The contraction in export buying of smalls has released a large tonnage for home consumption. Gas fuels are distinctly easier now that the post-strike demand for the replenishment of stocks has been met. Industrial consumption is on a lower level, due primarily to the easing off in the heavy engineering sections, but the railway companies are taking a big tonnage, and stocks at collieries are not large. The fact that several blast furnaces are still out of commission accounts for the lighter demand for coke. Orders for house coal are not numerous considering the season, but merchants have sufficient arrears to keep them fully occupied. Quotations: Best branch handpicked, 37*s.* 2*d.* to 38*s.* 2*d.*; Barnsley best Silkstone, 37*s.* 2*d.* to 37*s.* 8*d.*; Derbyshire best brights, 35*s.* 2*d.* to 36*s.* 2*d.*; Derbyshire house coal, 32*s.* 8*d.* to 33*s.* 2*d.*; Derbyshire best large nuts, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire small nuts, 31*s.* 8*d.* to 32*s.* 8*d.*; Yorkshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; rough slacks, 28*s.* 2*d.* to 29*s.* 2*d.*; nutty, 27*s.* 2*d.* to 28*s.* 2*d.*; smalls, 23*s.* 2*d.* to 24*s.* 2*d.*

Silicon Iron for Water-Vapour Experiments at 1,100 Deg. C.—In the *Zeitschrift für Elektrochemie* of October 1, Paul Askenasy mentions that he found silicon iron a very useful metal for experimenting with water vapour at temperatures up to 1,100 deg. C. for long periods. The iron tubes which he first tried were rapidly oxidised. Silicon iron, such as used by electrical engineers on account of its high resistance and low coercive force, is brittle. He had his tubes made as follows: The material was rolled hot down to 2 mm. thickness, and cut up hot; an experienced boiler-plater bent the strips red hot over mandrels, and welded the seam with plate scrap. The tubes were afterwards wound with resistance coils or directly heated as resistance, and they proved much less sensitive than iron to attack by high-temperature steam and oxygen. The tubes were utilised, in among other things, the manufacture of magnetite electrodes from pure iron; contact between the silicon iron and the iron to be oxidised was prevented by the interposition of pure clay or graphite.

Trade and Industry in Australia.—An address by Mr. S. W. B. McGregor to the British Empire Producers' Organisation was given on October 28, dealing with British trade and industry in Australia. The meeting was presided over by Mr. Ben H. Morgan, the chairman of the organisation. Mr. McGregor referred to the great industrial development of the Commonwealth in the last few years. The three main channels were wool manufacturing, the steel industry and the boot and leather trades, for all of which Australia has raw materials in plenty. In regard to the steel industry, people in this country, he said, had no idea of the great beginnings of a large industry which had already been made. Last year the principal steel works turned out 162,000 tons of pig-iron and 185,000 tons of steel ingots; 4,835 men are employed, and a capital of over 4,500,000*l.* is involved. In the matter of the Australian law which prevents an industrialist from contracting on this side with workmen to go to Australia, Mr. McGregor said that though he could make no pronouncement, he understood that this Act was not enforced to operate against the introduction of skilled labour into the country for Australia's new industries.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—There is little new to report concerning Cleveland pig-iron. Foundry qualities are as scarce as ever, and indeed are almost unobtainable for early delivery; and the lower qualities are plentiful but very slow of sale. Foreign demand for all descriptions of Cleveland pig-iron appears to have ceased. Sellers of foundry kind are keen to make forward contracts at current rates, but they find buyers backward and markedly disinclined to commit themselves ahead to any extent. For home consumption, No. 1 is 237*s.* 6*d.*, and No. 3, as well as the inferior grades of Cleveland, remains at 225*s.*

Hematite.—East Coast hematite is not easily purchased for early delivery, but there are plenty of sellers on forward account. In this branch also inquiry from abroad is very small. France and Belgium have become self-supporting, and adverse rate of exchange prohibits trade with Italy. To home customers No. 1 is 262*s.* 6*d.*, and mixed Nos. are 260*s.*

Foreign Ore.—Indication of early renewal of activity in foreign ore is not wanting, but at present business is on a very limited scale, being, in fact, confined to sales of spot cargoes. Consumers are carrying considerable stocks, and are consequently not in the market to buy for early needs, but some of them are by no means disinclined to negotiate for supplies over next year. The c.i.f. Tees value of best rubio is in the neighbourhood of 51*s.*

Coke.—Heavy local demand for coke is adequately dealt with, and consumers are now laying in stocks. Average blast-furnace kind is 62*s.* 9*d.*, and low phosphorus quality is 65*s.* 3*d.*

Manufactured Iron and Steel.—In finished iron and steel, business is difficult to arrange. Foreign competition is increasingly keen and successful, some articles from abroad being offered at pounds below quotations for home products. Manufacturers adhere to prices, which customers will not pay. Common iron bars are 30*l.*; marked bars, 32*l.*; iron angles, 30*l.* 15*s.*; steel bars, 24*l.*; steel ship, bridge and tank plates, 24*l.* 10*s.*; steel angles, 24*l.*; steel boiler plates, 31*l.*; steel joists, 24*l.*; steel strip, 30*l.*; channels and flats, 24*l.* 5*s.*; rounds and squares, 26*l.* 10*s.*; soft billets, 22*l.*; medium billets, 23*l.*; hard billets, 24*l.*; heavy steel rails, 25*l.*; fish-plates, 30*l.*; black sheets, 30*l.*; and corrugated galvanised sheets, 34*l.*

Shipments of Iron and Steel.—Shipments of iron and steel from the port of Middlesbrough during November totalled 30,189 tons, of which 12,643 tons were pig-iron, 1,506 tons manufactured iron, and 16,040 tons steel. The clearances coastwise were 3,031 tons of pig-iron, 150 tons of manufactured iron, and 1,260 tons of steel. For the previous month the shipments reached 55,244 tons, 26,235 tons being pig-iron, 1,909 tons manufactured iron, and 27,100 tons steel.

The Electro-Chemical Industry of Sweden.—From a statistical review of the chemical industry and trade of Sweden, published in the *Journal of Industrial and Engineering Chemistry* of November, by O. P. Hopkins, of Washington, we see that the hydro-electric power development of Sweden, though not on so grand a scale as in Norway, is an important factor in the prosperity of the country, and that plants have, as elsewhere, been increased during the war. The electro-chemical works rely on hydro-electric power. The following horse-powers are utilised in these industries: pig iron, 90,000; ferro alloys, 60,000; calcium carbide, 40,000; atmospheric nitrogen, 16,000; steel, 10,000; caustic soda and bleaching powder, 3,000; potassium salts, 2,700; graphite, 2,000; phosphorus, 1,800. The figures refer to the year 1918. The production of safety matches rose from 73,000,000 lb. in 1915 to 114,000,000 lb. in 1917; matches are an electro-chemical product, in so far as the phosphorus and the potassium chlorate are made with the aid of electric currents.

Explosion of a "Harmless Boiler."—Once again has a boiler, used on a farm for the purely agricultural purpose of threshing, proved that it is not exempt from the physical laws that govern other steam-containing, or pressure-containing vessels, though it is free from legislation, says *Canadian Machinery*, Toronto. It proved this elemental fact by the very impressive means of blowing up, fortunately without hurting anybody. The men in the immediate vicinity had a very lucky escape, and those who were further away were also fortunate, as some pieces weighing several hundred pounds were reported to have landed several fields away. It shows surely a lack of consideration, or a sense of fitness of things, on the part of these boilers to blow up when several successive Governments have decided, in their wisdom, that these boilers cannot blow up, and are perfectly harmless domestic pets. The process of reasoning which decided that because a boiler is on a farm it is going to act differently under given circumstances than a boiler in an industrial establishment, is not very clear to the ordinary mortal. Furthermore, the boiler on the farm is supposed to be possessed of sufficient intelligence to enable it to perform its functions without the aid of any skilled help. It is very likely that the real reason of the exemption of boilers on the farm from the Steam Boiler Act was on account of the farmers all possessing votes, and the fact that a farmer suddenly called upon to pay inspection fees, and probably higher wages to skilled help, would have emitted a howl that would have been heard uncomfortably in Government quarters.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—The prevailing trade conditions have militated against any expansion in the Scotch steel trade during the past week and little change has taken place. The works are all very well employed, and quite a lot of stuff of one kind and another is being turned out, but most of it is against contracts fixed up some time ago, and the future is what gives concern to the producers. At one time the bookings amounted to a very large tonnage and covered a considerable period ahead, but the cancellation of so many contracts for new tonnage caused a considerable falling-off in the forward demand for steel material. The arrivals of consignments of the foreign product at lower prices than those named by home makers have also accounted for a part of the decline locally, and the recent reduction in prices was expected to steady things a bit, but that has not brought out much fresh business so far. Buyers are undoubtedly holding back in the hope of a further decline in quotations, and in that case bookings will remain on the small side, in the meantime, unless producers hold out further inducements for forward contracts. The demand for ship-plates has been quite good of late, but as the prospects in the shipbuilding industry are none too bright that source of outlet must be considerably discounted by producers. For boiler plates there is a fair outlet, but the demand for structural sections has reached a low ebb, and there is very little business passing. Makers of black sheets are very quickly overtaking contracts on hand, and no great amount of booking is reported, so that the outlook is not quite so bright as it might be. Galvanised sheets show no change and are very quiet. Export business on the whole is poor and shows little sign of picking up.

Malleable Iron Trade.—A much easier tendency prevails in the West of Scotland malleable iron trade, and there is no pressure for deliveries. The outlook is not too encouraging because new business is not being booked anything like equal to to-day's output, and unless there is some improvement difficult times are ahead. Prices are steady and unchanged.

Scotch Pig-Iron Trade.—The position of Scotch pig-iron is undoubtedly still very strong owing to the scarcity of all the higher grades. The demand is strong, but the amount available is improving, and before long it is hoped to be able to meet all requests. There is little doing in export, as so much is required at home, but foreign buyers are anticipating a decline in prices and are meantime holding back.

Scotch Shipbuilding.—The shipbuilding returns of the different districts in Scotland for the past month are very satisfactory, when the conditions which prevailed in the labour market are remembered. The total output was 33 vessels of 73,582 tons, making 285 vessels with a total of 658,728 tons for the year to date, which compares very favourably with the output of 582,501 tons for the same period of last year, and 671,230 tons for the record year of 1913. The figures for last month, with the total for the year to date, are as follows :—

	November, 1920.		Eleven Months, 1920.	
	Vessels.	Tons.	Vessels.	Tons.
The Clyde	25	48,047	204	565,088
The Forth	4	13,010	32	57,568
The Tay	2	10,925	9	23,643
The Dee and Moray Firth	2	1,600	40	12,429
	33	73,582	285	658,728

The Clyde figures for the past month are rather under the average monthly output for this year, but the total of 48,047 tons is very good indeed when everything is taken into consideration, and it brings the year's output up to 565,088 tons. While that total is 42,675 tons ahead of the corresponding eleven months of last year, it is still 63,728 tons less than for the year 1913, and is actually 191,888 tons behind the full output for the whole of the latter year. There is still a large amount of work on hand but fresh contracts seem almost to be a thing of the past, as few or none have been fixed up for some time back. With materials showing an easier tendency shipbuilders are now in a position to give slightly lower quotations, but it is doubtful if much new business will be placed yet awhile. Labour is still unsettled, and now the shipyard joiners have gone out on strike, which, if continued will cause dislocation in the industry.

"TANK STEEL."—We read in *The Iron Age*, New York, that tank steel has been defined by a committee of the Association of American Steel Manufacturers "as a grade to be used for ordinary fabrications or for structural purposes where no particular stresses are required. It should be free from injurious surface defects." The necessity for making a definition seems to have arisen through the fact that an increasing number of buyers were specifying tank steel and then adding requirements that would throw the material into a higher classification, without, of course, expecting to pay the extras required by such higher classification. The ruling of the committee is further that if the buyers' specifications stipulate a tensile test from each plate as rolled, the material shall be classified as flange steel. Further, that if a flange steel purchase specifies a homogeneity test in addition to naming chemical and physical properties, the material becomes fire-box steel. Again, that if the steel plate order carries specifications with regard to phosphorus and sulphur limits equivalent to the fire-box grade, the steel shall be regarded as fire-box steel unless the chemical tests are modified.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—The outstanding feature of the export coal trade in the past week was the abrupt termination to the controversy in respect to French coal contract prices over 1921. The dispute arose over the issue by the Bureau des Charbons, the authority responsible for the import of coal into France for industrial purposes, of a scale of maximum f.o.b. prices, many shillings per ton below current market values, at which they were prepared to consider contracts for 1921. As British exporters were virtually bound to supply 45 per cent. of the total exports to France, under an agreement reached between the British and French Coal Controllers some months ago, the decision of the Bureau was an important matter for colliery owners and exporters. It was agreed that while France had every right to take what measures were considered necessary to obtain cheaper coal, freedom should also be restored to British exporters in respect to the destination of exports. The French Coal Controller and the British Minister for Mines, at a meeting in London on Friday, considered the matter, and an agreement was reached under which it was agreed "that while on the one hand the French Government is at liberty to frame such internal regulations as it may deem proper in respect of import prices, British coalowners and exporters must on their part be free to accept or refuse the prices offered by the French importers." It was also agreed that the British Government is now under no obligation to reserve 750,000 tons, or any specific quantity, for shipment to France, but that the obligation to supply Italy with 20 per cent. of exports, estimated at 350,000 tons per month remains. The effect of this agreement is that for the first time since the war coalowners and exporters are now free to dispose of the exportable surplus without reservation as to destination, with the exception of the monthly quantity allocated to Italy. What effect this important change will have on the market remains to be seen. The alteration has come at an inopportune moment, for most of the foreign countries are stated to be fairly comfortably placed in regard to coal supplies, though it is impossible for large stocks to have been accumulated, and are refusing to place new orders at current prices, while those not too well placed are waiting in the hope of seeing lower prices. American coals are reported to be freely offered to Continental buyers at prices considerably below those demanded a couple of months ago.

No slump has yet set in for the best quality coals, but inferior grades are obtainable for quick loading at about 20*s.* per ton less than was the case a few weeks ago and, even at these lower prices, sellers find it difficult to obtain fresh orders. On paper most collieries are fully stemmed, but owing to increased outputs and inadequate loading facilities at the docks sellers are in many cases compelled to cut prices to buyers able to take quick delivery in order to get wagons back to the collieries promptly. Foreign cargo exports in the past week, at 368,965 tons, were the highest since February last, and it will not be surprising to find the current week's shipments greater still, for the quantities permitted for foreign shipment have been increased from 2 per cent. to 7½ per cent. Patent fuel makers in Britain, France and Belgium have decided to appoint a central buying agency for the purchase of pitch, used in the manufacture of fuel, because of the high price demanded for pitch. Before the war pitch was obtainable at about 30*s.* per ton, but has advanced to 260*s.*, which is considered an unreasonable figure.

THEORY OF THE SOLID STATE OF AGGREGATION.—That solid bodies remain solid under ordinary conditions is commonly ascribed to the mutual attraction between the molecules. This attraction can be overcome by heat and mechanical stress. In the hot body the molecules rotate at faster rates about their equilibrium positions, and the atoms acquire a higher energy of motion, until the body softens and melts; the heat energy required can be measured in calories. When a solid is broken by pull, shock, shear, &c., there is no uniform measure for the mechanical strength; the correlation of the strengths deduced from various testing methods is still obscure. Yet it is felt that liquefaction and mechanical fracture are both separation processes which will ultimately have to overcome the same forces of attraction. In the *Zeitschrift für Physikalische Chemie* of July 31 last, A. van der Werth, Darmstadt, attempts to interconnect these two strengths, which may be briefly designated as thermal and mechanical. Arranging the metals as to decreasing specific heat he finds the order Ni, Co, Fe, and so on, nickel having the highest specific heat of all the metals. The modulus of elasticity gives a similar sequence beginning with Ni, Co, Fe; but Pt follows next with a high modulus, yet with low specific heat, whilst aluminium has a high specific heat and a low modulus. When the work done during expansion is calculated from thermal data, the order is found to be Pt, Fe, Ni, Pd, whilst from the modulus the order is Ni, Fe, Pt, Cu, &c. That the modulus values for this work are all smaller than those deduced from the specific heat might be concluded from the fact that mechanical stress mostly acts only on a small portion of a body whilst the heating affects the whole; but the two sequences are not the same. As regards the conductivity of a metal for heat and electricity and its mechanical strength comparative calculations can hardly be made. Van der Werth points out, however, that the best conductors (Au, Cu, Ag) are of medium fusibility and mechanical strength; low melting-point and low strength (Zn, Sn, Cd, Mg, Na) go together with fair conductivity, and high melting-point and high strength with rather poor conductivity (ferrous metals).

NOTICES OF MEETINGS.

INSTITUTION OF MECHANICAL ENGINEERS.—Friday, December 3, at 6 p.m., at Storey's Gate, St. James' Park, S.W. 1, further discussion on Mr. A. Ramsay's paper read at the Lincoln Summer Meeting on "The Human Factor in Industry."

THE INSTITUTION OF BRITISH FOUNDRYMEN.—LANCASHIRE BRANCH.—Saturday, December 4, at 4 p.m., in the College of Technology, Manchester, when Dr. F. J. Brislee, of Roby, Lancashire, will give a paper on "Modern Metallurgical Investigation."

THE MINING INSTITUTE OF SCOTLAND.—Saturday, December 4, at 3 p.m., in the Royal Technical College, George-street, Glasgow. Mr. R. H. J. Conacher's paper on "A Marine Limestone occurring within the Hurlet Coal Seam" will be discussed; Mr. William Campbell's paper on "Coal Veins in Peru" will be discussed; Mr. H. M. Cadell, B.Sc., F.R.S.E., will read a paper, illustrated by lantern slides, on "Coal Mining in Spitzbergen"; a demonstration will be given of "The Hulley Patent Mine-Dusting Machine."

THE INSTITUTION OF CIVIL ENGINEERS.—YORKSHIRE ASSOCIATION OF STUDENTS.—Monday, December 6, in the Lecture Theatre of the Brown-Firth Research Laboratory, Sheffield, when Mr. Terrey, M.Inst.C.E., general manager of the Sheffield Corporation Water Supply, will read a paper entitled, "History and Description of the Sheffield Waterworks."

THE ROYAL SOCIETY OF ARTS.—Monday, December 6, at 8 p.m. Cantor Lecture. "Micro-Organisms and Some of their Industrial Uses," by Mr. A. Chaston Chapman, F.R.S., F.I.C. (Lecture II); postponed till December 13. Tuesday, December 7, at 4.30 p.m. Colonial Section. "The Trade of Australia during and after the War," by Mr. A. H. Ashbolt, Agent-General for Tasmania; the Right Hon. Sir William Ellison-Macartney, K.C.M.G., Governor of Tasmania, 1913–17, Governor of Western Australia, 1917–20, will preside. Wednesday, December 8, at 4.30 p.m. Ordinary Meeting. "A Retrospect of the Personal Influence of Britons in Russia," by Mr. E. A. Brayley Hodgetts, chairman, Russian Section, London Chamber of Commerce; the Right Hon. Lord Carnock, G.C.B., G.C.M.G., G.C.V.O., K.C.I.E., Ambassador to Russia 1906–10, will preside.

THE SHEFFIELD ASSOCIATION OF METALLURGISTS AND METALLURGICAL CHEMISTS.—Tuesday, December 7, at the Leicester Room, Sheffield, a paper on "Carbon and High-Speed Tool Steel," by Mr. F. C. A. H. Lantsberry, M.Sc., F.I.C., will be read and discussed.

THE ASSOCIATION OF ENGINEERS-IN-CHARGE.—Wednesday, December 8, at 7.30 p.m., at St. Bride's Institute, Bride-lane, Fleet-street, the president-elect, Mr. W. H. Patchell, M.Inst.C.E., M.I.Mech.E., M.I.E.E., upon taking office, will address the members in an informal talk, relating to his recent American tour, illustrated by lantern slides.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, December 9, at 6 p.m., at the Institution of Civil Engineers, Great George-street, Westminster, S.W. The Distribution of Electricity," by Mr. W. B. Woodhouse, and "Some Economic Aspects of E.H.T. Distribution by Underground Cables," by Mr. R. O. Kapp. Adjourned discussion.

THE TECHNICAL INSPECTION ASSOCIATION.—Friday, December 10, at 7.30 p.m., at the Rooms of the Royal Society of Arts, John-street, Adelphi, a paper will be read by Dr. H. G. Gulliver, B.Sc.London, D.Sc.Edin., on "Some Features of Tensile Fractures."

JUTE MANUFACTURE IN SOUTH AFRICA.—It is not generally known that the wild jute of South Africa, hibiscus cannibinus, grows as a weed in many parts of the Union, and that a small company has been floated to test and develop the industry. This is being done near Hector Spruit, says *The South African Mining and Engineering Journal*, and reports of the crop are very encouraging. Should this industry develop it opens out large possibilities, and ultimately may be in a position to supply all the jute goods required by the Union, in addition to providing employment for a large white and black population. It is also interesting to note that this weed was introduced from South Africa to India, and to-day forms a considerable proportion of the jute goods produced there.

MANCHESTER ASSOCIATION OF ENGINEERS.—On Saturday, November 27, a paper was read before the Manchester Association of Engineers, on "Modern Developments in the Manufacture and Utilisation of Coal Gas," by Messrs. F. J. West, C.B.E., and T. A. Tomlinson, M.B.E. This paper was illustrated by lantern slides and by the cinematograph. It was divided into three sections, the first of which dealt with the principles and products of carbonisation. The second section described the modern apparatus in use, and the third dealt with the applications of gas to domestic and industrial purposes. The first section gave analyses of coals and the products of carbonisation. The apparatus described included the horizontal retort, the incline retort and the vertical and continuous vertical retort systems, a full description of the Glover-West system being given, and illustrated liberally by means of lantern slides. For an industrial centre such as Manchester the part of the paper dealing with industrial applications appeared to dismiss this part of the subject in a somewhat summary fashion.

ELECTRICALLY-OPERATED EXCAVATOR ON THE QUEENSTON-CHIPPAWA HYDRO-ELECTRICAL CANAL.

CONSTRUCTED BY THE BUCYRUS COMPANY, ENGINEERS, SOUTH MILWAUKEE, WIS., U.S.A.

(*For Description, see Page* 734).

FIG. 1. EXCAVATOR AT WORK ON A 70-FT. FACE.

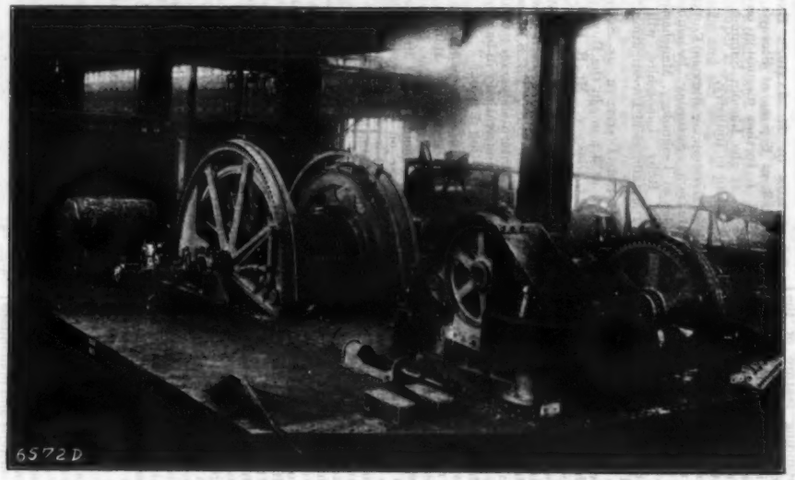


FIG. 2. REVOLVING PLATFORM, SHOWING WINDING GEAR AND CONTROL PANELS.

FIG. 3. DUMPING SPOIL INTO TRUCKS BETWEEN 60 FT. AND 70 FT. ABOVE EXCAVATOR RAIL LEVEL.

FIG. 4. PART OF THE HYDRO-ELECTRIC CANAL CUT.

2-8-0 TYPE SUPERHEATER LOCOMOTIVE FOR

CONSTRUCTED BY MESSRS. SIR W. G. ARMSTRONG, WHITWORTH

(For Description, see Page

Heating S

Fig.1.

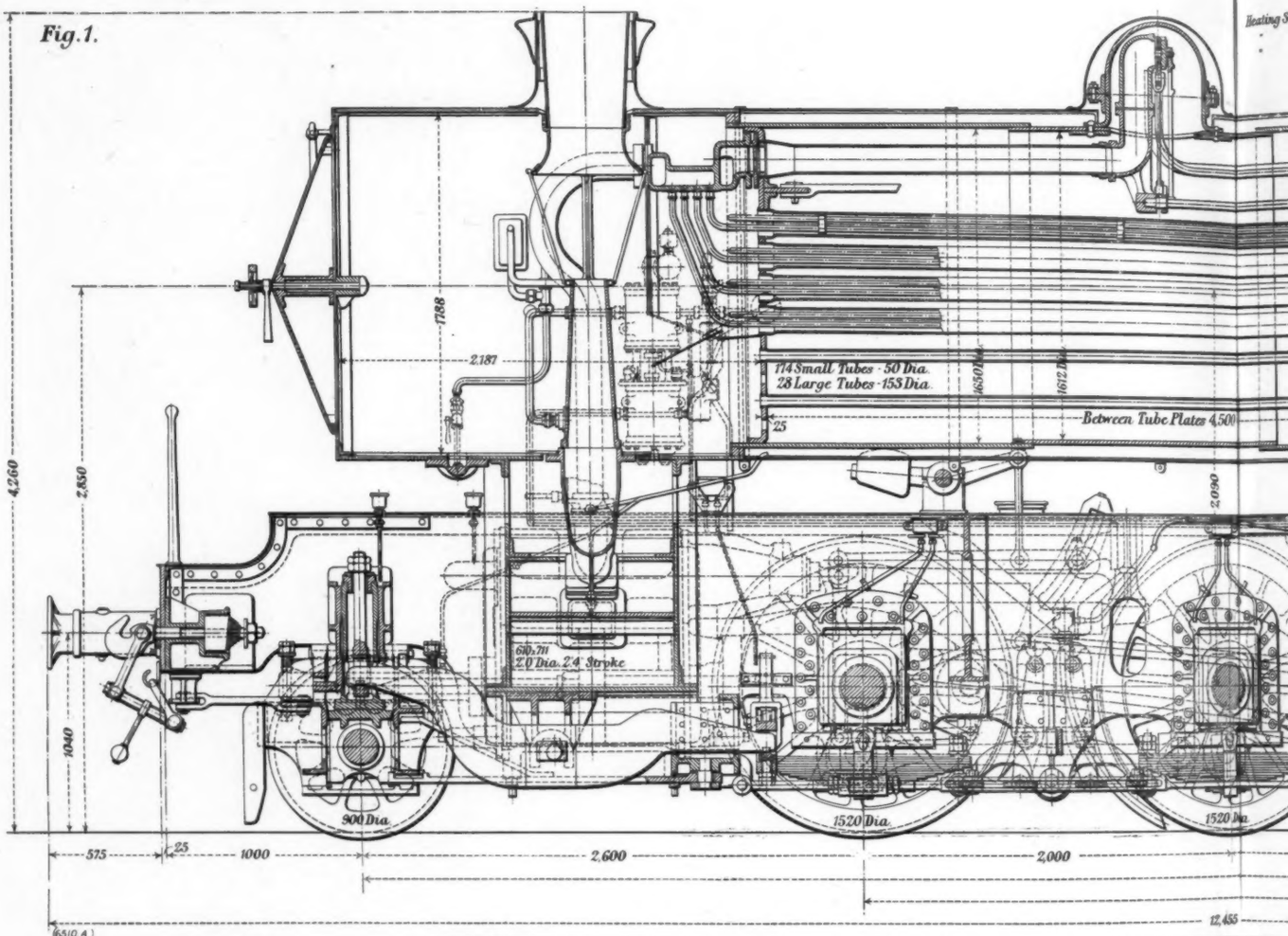
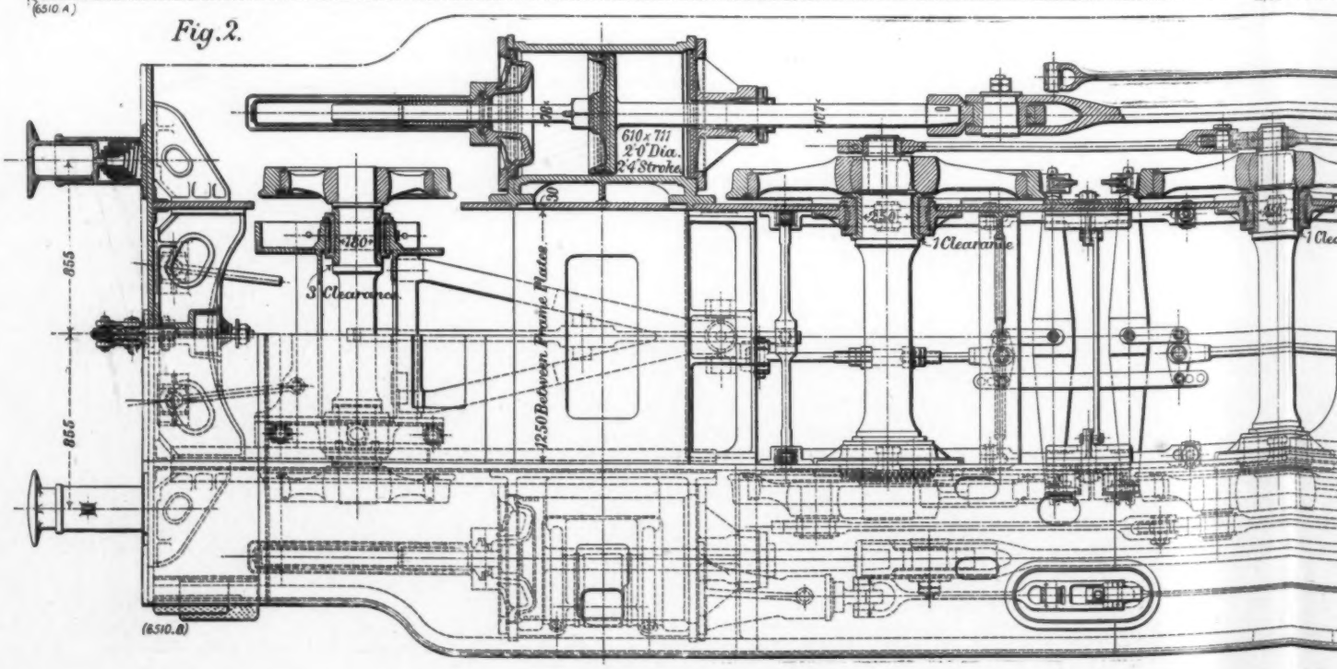


Fig.2.



VE FOR THE BELGIAN STATE RAILWAYS.

G, WHITWORTH AND CO., LIMITED, ENGINEERS, SCOTSWOOD.

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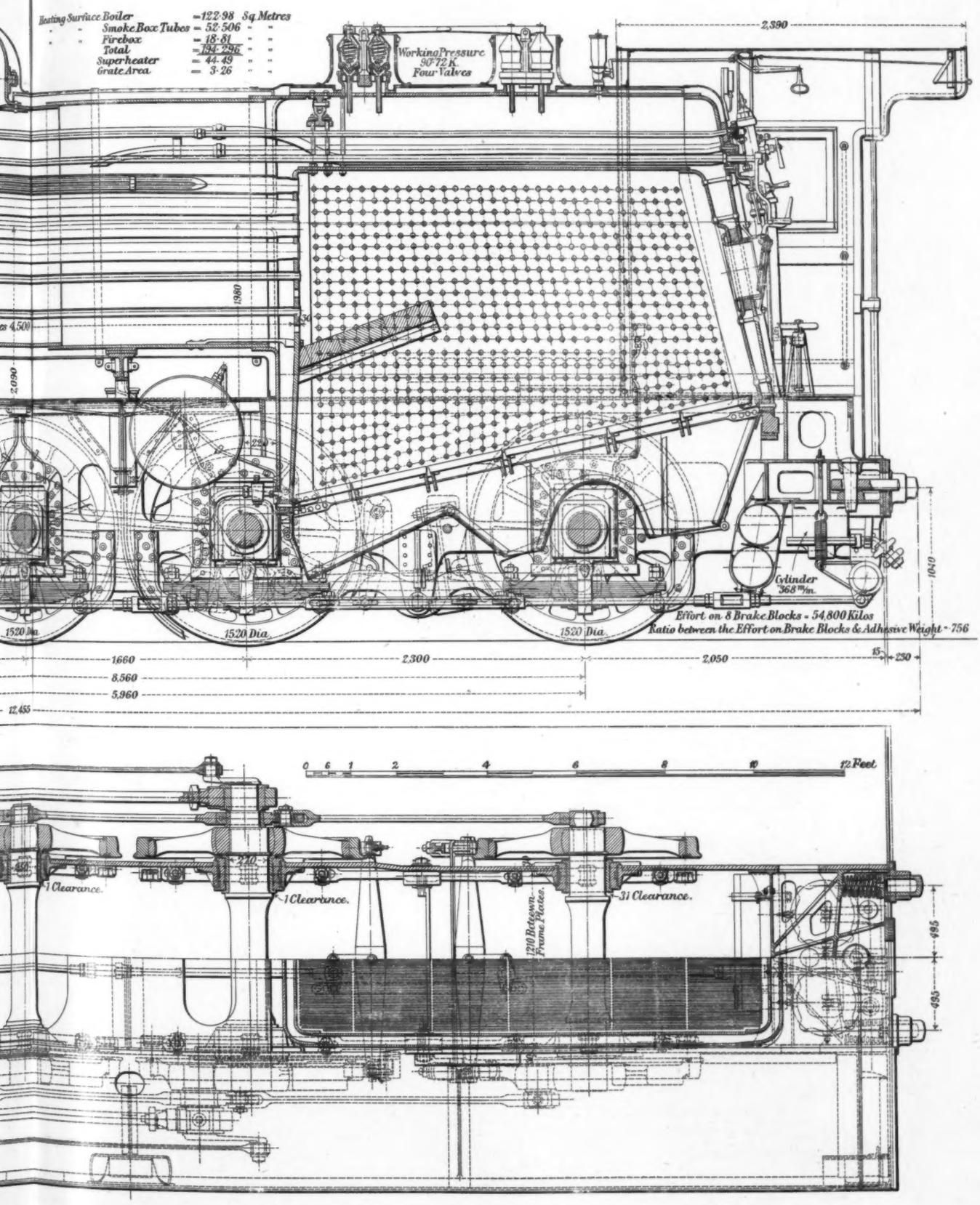

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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

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NOTICE.

A few months ago the Proprietors of "ENGINEERING" were compelled to advance the price of this Journal to 1s. per copy, owing to the enormous increases in the cost of paper, engravings and printing, &c. Now higher transport and delivery charges involve a further increase to 1s 2d. per copy, and this price dated from and included the issue of Friday, April 2, 1920. As the postal rates have been again increased, the price of single copies sent by inland post is now 1s. 2½d.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of Supplies, Newsagents will not have copies for chance customers; therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 739.

ENGINEERING.

FRIDAY, DECEMBER 3, 1920.

A GOVERNMENT POWER SCHEME.

STRANGE as many official actions are now-a-days, few have struck us as so singularly out of place as the manner in which the country was informed last week of the proposal to embark upon a large tidal power scheme on the Severn. We are not so much concerned for the moment with the scheme itself, whatever merits it may ultimately prove to possess, as with the method which the Ministry of Transport has seen fit to adopt in connection with a matter of great weight and high technicality. The tone of the curious document which issued from this Ministry, dilating on this scheme, made us turn over its pages mechanically, as one would with a company promoter's prospectus, to find out how much capital it was intended the project should swallow up. Our search was not attended by success. Neither could we discover therein a particle of technical data, nor yet the name of any responsible person attached to it. In fact, apparently beneath the notice of His Majesty's Printers, the notes distributed seem to have been considered by the Ministry itself, only fit for some office duplicator in Whitehall Gardens.

In highly speculative circles, the subtle creation, in advance, of a favourable impression is not infrequently indulged in, but the custom has been so often associated with the less reputable side of finance that it is seldom countenanced by self-respecting concerns, and its use is therefore almost sure to arouse suspicion. That the official language adopted in this extraordinary case is also likely to discredit the department concerned may be gathered from a few quotations, for it suggests that someone has settled in Whitehall whose office should properly be in the purlieus of the city. We find, for instance, this composition headed "The World's Greatest Water Power Scheme," "The Gate of the West," "A Paying Proposition," while, on dipping further into it we are told that this is "the first scheme . . . to utilise the rotating forces of the earth," and "to snatch part of the movement of the earth and put it into gearing to turn machinery." It is said to be planned on a "sound economic basis" and to offer "limitless vistas," "bringing the blessings of Light, Purity and Power within the reach of all classes of the community." Such extravagance of language is altogether at variance with what one would expect from the dignified and careful deliberations of a responsible Government Department. One can only conclude that this clap-trap is designedly intended to convey to the public the idea that the Ministry is vastly alive, and immensely busy with wonderful and original reforms.

The careful avoidance of all technical data in this document, while at the same time specious reference is made to engineering points in a manner clearly intended to clothe the whole with an air of verisimilitude well calculated to impress a credulous public, indicates the standard of intellect to which this Ministry thinks it best to make its first appeal. It cannot, however, be congratulated on having, in any sense, added lustre to its office by this performance.

It will be time enough to consider the scheme itself when the promoters see fit to back it with estimates of cost. Several days have now passed, but no endeavour has been made to supply even a rough estimate of this. At present it is only possible to surmise that the project requires plant of a capacity of about four times the normal load of 500,000 h.p. Everything connected with it is described as either "immense," "gigantic," or "enormous," including the dams, pumps, &c., to say nothing of the 40-ft. tunnel for the water for the "great inland lake." An "Army" of men running into thousands of all grades, for many years would be employed, and so, whatever happens, we may be fairly sure that the cost, too, would be colossal. We can hardly get away from that fact, and it is very doubtful if the present is at all a suitable time for further national expenditure. It looks very much as if the whole thing were intended to be something in the way of a political reply to the oft-repeated charge made against the Government, of extravagance and waste. With the country becoming weary of heavy national expenditure, the Ministry would, we believe, be well advised in placing their facts, whatever they may be, before the country, when we are inclined to think that if the scheme should prove attractive after careful scrutiny, it might be left to private enterprise. We believe it to be the unfortunate fact that such projects do actually come within the all-embracing Ministry of Transport Act. The whole affair has a very ominous ring about it, suggesting that decisions have already been arrived at. The reiterated use of the definite words "is" and "will be," in the description of the plans, in place of the more problematic "would" or "could," would almost indicate that the work is even now in hand. We trust that the Ministry has not abused its trust so far as that, but after this exhibition of the treatment it thinks suited to national questions and responsibilities we are almost inclined to despair of it altogether.

Since the issue of the unfortunate document which we have felt it our duty to criticise above, the Ministry has disclosed something more of its plans. In the House of Commons, Sir Eric Geddes has stated that the scheme would find employment for 10,000 men for seven years. We leave it to our readers to make the simple calculation what the cost of labour alone would therefore be at present rates of wages. Further, yesterday we received from the Ministry a document, for some reason marked "Unofficial," giving a few details of the idea in a considerably modified tone, but still lacking many of the main technical essentials, and especially the all-important particulars of cost.

From this document we learn that it is expected to utilise the barrage turbines for 7 hours with heads varying from 5 ft. to 30 ft., the latter occurring only, of course, at spring tides. The machines would generate 1,300 kw. each, which, for the normal load, and without the surplus plant to meet the demand for pumping, suggests that there will be quite a number of these units in the barrage installation. We note also that the suggestion is made that 500,000 kw. can be transmitted to London; at the same time it can all be consumed in South Wales, or in the Birmingham District, a point on which clearly some decision must be arrived at or the cost of the longer transmissions will off-set any object in supplying distant markets. The dynamos at the dam will be variable-speed generators, producing direct current at a constant voltage of 525 volts. The turbine speeds of approximately 40 r.p.m. to 80 r.p.m. will be geared up to give 300 r.p.m. to 500 r.p.m. for the generators. The direct current will be converted to alternating at 330 volts by rotary converters. Static transformers would step this up to 60,000 volts for transmission to the industrial centres, &c., which it is proposed to supply. When excess power is produced at the dam it will be transmitted to the pumping station 10 miles distant, where it will be consumed in pumping water up to the inland lake. At this pumping station the plant proposed consists of pumps, turbines and motors arranged for use

also as generators, in order to reduce the installation as far as may be, the plant being capable of a peak output of 1,000,000 h.p. It will therefore be seen that the amount of machinery will be very considerable indeed.

It is claimed that in the scheme the only machines not running always at full load will be the dynamos at the barrage, but as these will run into several hundreds, the conditions under which they work will constitute an important factor. The units at the pumping plant are planned as 13,000-kw. machines working at 2,200 volts and 375 r.p.m. The head under which the turbines here would work, and against which the pumps would have to operate is not given, but the tunnel, 40 ft. in diameter, is said to be about a mile in length through rock.

It will be clear from the labour cost, the multiplicity of units at the dam and duplication of the plant at the pumping station, the cost of tunnelling, &c., to say nothing of the dam itself, and the separate railway and road viaduct, with the locks and lock machinery, that the scheme would run the nation into vast expenditure to attain results which are by no means certain to secure a profitable selling price for the current generated.

THE PERFORMANCE OF ELECTRIC FURNACES.

The steady growth in the number of electric furnaces in use and the very rapid increase in yearly output of electric steel which has been taking place in Europe and America show that electrically-melted steel has a definite place in the steel industry, where it can compete with pre-existing processes and even successfully displace them. The electric furnace has forced its way into the circle of the economically sound systems, notwithstanding the adverse criticism and destructive prejudice of its detractors, and almost in spite of the lavish praises of the selling agencies, because advantages have been claimed for it which it never possessed, and its real advantages are only now coming to the front.

During the war an abnormal development took place owing to its suitability for using up the enormous quantities of turnings from shell manufacture which drugged the market, and as is usual with quick growths weaknesses soon became apparent. For these weaknesses in its development the whole blame was put on the electric furnace, when it often lay elsewhere, the furnace makers themselves being partly responsible through their over-confident assertions and ignorant claims. One very serious error was the inference, sedulously spread at one time, that the steel made in an electric furnace was always of the very best quality—turnings or any old kind of scrap submitted to the magical influence of the electric arc became at once the steel par excellence for any and every purpose, and those who had been led to believe this and found to their cost that the statement was based more on optimism than truth, turned round and heaped their curses on the offending process, at the same time in many cases going back to the older processes of steel-making, which they understood through long familiarity. And those who thus acted cannot well be blamed for their attitude, for it is now generally appreciated that it is just as easy to make bad steel in an electric furnace as in a furnace of any other type, and that to make good steel requires training and a knowledge of the properties of liquid steel, as well as a knowledge of the type of furnace in use. What must be regretted is that it will take a long time to bring confidence back to these twice-shy people who have been once bitten. Such confidence can only be restored by the publication of the actual results obtained by users who have had more skill or perhaps a little more perseverance. There have been very few unbiassed reports on this subject. One of the best is that of Mercer* on the output statistics of most of the furnaces in use in this country during the war, while another most informative report has recently been published by Commander Cleary, in the Journal of the American Society of Naval Engineers for May last.

In 1918 the American Navy Yard at Mare Island bought a 6-ton Greaves-Etchells furnace at a cost of 47,500 dols. plus an allowance to the contractors of 5,960 dols. for erecting, and in the report just mentioned the full details of output and costs of working of this furnace are given for the first 50 heats. Only one heat per day was made during this period so that the figures represent what took place during very unfavourable conditions, because they were the development conditions when the plant was new and the men were not accustomed to their duties, and it is not the normal condition to run only one heat per day in a furnace. The steel was used for ingots and castings, and the average time for a heat seems to have been about 5 hours, the furnace being charged immediately after the previous day's heat. Of 100 per cent. material charged into furnace there was obtained from the ladle 96·82 per cent., leaving a furnace and ladle loss of 3·18 per cent.; this indicates quite good working, and under more practical conditions would be considered satisfactory. The electrode consumption over the whole 50 heats is returned at 40·9 lb. per short ton, but this includes the initial period of starting. Omitting the first 10 charges the consumption is reduced to approximately 19 lb. per short ton of material charged into furnace. Allowing for the furnace loss and the short ton this consumption would come out roughly at 22 lb. per British ton.

Turning to the current consumption, the average for 50 heats was 1,020 units for melting and refining 62·2 units for preliminary heating and 8 units for auxiliaries, such as tilting motors and electrode motors, a grand total of 1,092. Under continuous working this would be reduced materially, but it would still leave the cost of current the principal item in the cost of production.

Power station engineers when their attention is drawn to this fact are inclined to argue that there is room for greater economies in the general operation of electric furnaces than could be obtained by a reduction in the cost of the current, and until these are effected they cannot be expected to reduce their charges for the electrical unit. Although this may be true, economies in current and current charges still remain the most important means of reducing the production costs of electric steel. In some concerns in America the price of power is based on the load factor, which is a reasonable basis from many points of view. The load factor for a single furnace is, however, only about 20 per cent. under the best conditions, but a group of furnaces materially increases this, and with six to eight furnaces on the same supply it should be possible to obtain an average load factor of over 80 per cent. over long periods. Electric steel production on a large scale, therefore, would tend to remove some of the most important hindrances to cheaper production.

A very valuable feature of the report with which we have been dealing is the extensive information given regarding the details of the costs of production in this furnace for the initial 50 heats. Based on accurate records, the averages were as follow:—

Operation.	Dollars.	Percentage.
Scrap	6·993	17·20
Metallic additions ...	3·315	8·16
Slag-forming additions ...	1·387	3·41
Electrodes	3·578	8·82
Power	13·627	33·56
Labour	7·678	18·80
Total	36·578	89·95
Maintenance.		
Bottom refractories ...	0·484	1·19
Roof	0·680	1·67
Walls	1·142	2·81
Tools, oils, &c.	0·200	0·49
Labour	1·535	3·79
Total maintenance ...	4·041	9·95
Total cost	40·62	99·90

In this table there are no charges for on-cost, supervision or depreciation. Also it is assumed that the scrap returned from the foundry is returned to the furnace free of cost; this is quite wrong. Allowing for this scrap at the same price as the other scrap used, it brings the total up to 43·237 dols. per ton, charged into furnace, or 44·666 dols. per ton of liquid steel delivered into the ladle. The conditions existing were, of course, not those under which a commercial plant would normally run, but they have the great merit of being authentic and the result of actual practice.

It is difficult to estimate the actual production costs, as no details are given of overhead charges. The figure taken by Commander Cleary is 100 per cent. of the total detailed charges for material, labour, fuel and repairs, which works out at roughly 42 dols. per short ton. For supervision, &c., a more usual charge would be 150 per cent. of labour charge, which would bring it to 13·8 dols. per ton, a very marked difference. Under the abnormal conditions of running this particular furnace, the cost may be as high as 86 dols. per short ton; under continuous output conditions, it certainly would not be higher than 58 dols. per ton, and might be 5 dols. or 6 dols. less. For comparison purposes it may be stated that ingots of forging quality were selling at that time in Pittsburgh for 48·50 dols. per ton.

The values are sufficiently close to show that electric steel for qualities a little better than ordinary commercial brands is likely to become of increasing importance in the world's markets as the technique of its production is improved and economies are effected in minor details of the plant, but in any case it will always be of importance for manufacturing certain types of steel which cannot be produced in the open-hearth furnace, and that it will eventually displace the crucible process almost completely seems to be fairly assured.

ENGINEERING SCHEMES IN PARLIAMENT.

The programme of engineering works for which sanction is to be sought in the next session of Parliament is in general of a very humdrum character, though much of the work will involve considerable expenditure. There is no doubt as matters stand, little inducement for men of "push and go" to prepare plans for increasing the national wealth by undertaking public works requiring parliamentary sanction, as the most promising schemes are likely to be rejected either because they may compete with undertakings controlled by unimaginative and unenterprising public bodies or because it is held that services of the kind contemplated should not be undertaken for private profit, the result being that as public bodies will not face the pioneering risks, nothing is done, and our whole industrial development is retarded. Of course the high rate of interest at present demanded constitutes another check to enterprise, as does also the high cost of labour, since in this country we have not yet learnt, as the Americans have so frequently succeeded in doing, to combine low labour costs with high rates of pay. In illustration of this it may be noted that in spite of higher wages American prices for first-class road metal are but one-half those ruling in this country. In view of the very large amount of road and street work contemplated in the immediate future, this discrepancy is in urgent need of rectification.

But few of our railways are promoting bills this session. The railway situation is unfavourable for development, both on account of the uncertainty of the future and the settlements of past claims against the Government. The London and North-Western Company have a bill amending their order of 1913 authorising the construction of the Wolverhampton and Cannock Chase Light Railway. An extension of time for its construction is demanded and authorisation for certain deviations in Wolverhampton and Wednesfield of the route originally proposed. The North-Eastern Company seek sanction for a large amount of widening work. Thus their Newcastle and Berwick line is to be widened at Belford, Alnemouth and Wallsend, whilst at Gateshead new junctions are proposed between the company's Dunstan branch and their Gateshead line and with their Redheugh deviation. The Seaton Snook branch is to be widened on both sides in the Hartlepool area; and the Port Clarence branch, near Haverton Hill, whilst a loop to the Darlington and Saltburn Railway, is to be constructed at Lazenby. Widenings of the York and Newcastle line are proposed between Darlington and Croft and between Otterington and Northallerton. At the latter place the Leeds line is also to be widened. Other widenings of the York-Newcastle line are to be made between Sessay and Thirsk and between Pilmoor

* See Engineering, May 15, 1919, page 629.

and Sessay. At Northallerton a new junction is to be constructed between the Hawes branch railway and the Leeds northern line. The bill also sanctions a number of widenings and improvements already made, presumably during the war. The North Staffordshire Railway Company have a bill authorising new junctions between their Potteries loop and the Macclesfield and Stoke line, and the company's Ashbourne branch is to be diverted for about ¼ mile near Rocester Junction.

Not much new tramway work is proposed, but perhaps rather more than might have been anticipated in view of the past record of these undertakings. The only striking scheme is one promoted by the Durham County Council, which proposes to link up the lines at Gateshead with those at Durham, passing along the main road through Chester-le-Street. Another line will start from the metals of the existing tramways at Jarrow, and passing through Boldon will connect up with the existing trams at South Shields and Sunderland. In addition a number of trackless trolley lines are to be installed, presumably where the traffic is deemed insufficient to justify the cost of tramway tracks. One of these trolley lines will connect Gateshead with Consett, and a second will pass from Gateshead to Chester-le-Street *via* Pelton, Beamish and Tanfield. Another route proposed is from Chester-le-Street to Houghton-le-Spring; whilst services are also to be established between Spennymoor and Bishop Auckland, Durham and Houghton-le-Spring and Felling and Washington. No doubt an important element in deciding the County Council to embark on the enterprises above set out is the cheap rate at which current is supplied by the North East Coast power companies, their charge being on the average about one-third as much as is demanded by the municipal stations with which Lancashire has burdened herself.

The foregoing describes the only really new tramway work that is contemplated, the remainder being merely extensions of existing borough lines. Such extensions are proposed in Aberdeen, Grimsby, Hastings, Leicester, Liverpool, Rotherham and Wigan. The corporation at the town last named have also a scheme for a trolley service to Aspull. This seems to be the only trolley proposal in addition to those made by the Durham County Council. A large number of towns are seeking powers for the running of motor-bus services into the rural areas surrounding them, but none of the proposals appear to be of other than purely local interest. An item of interest in the history of transport in this county is the proposal of the Leeds and Liverpool Canal Co. to abandon and close the Bradford Canal navigation, authorised in the eleventh year of George III., "for making a navigable cut or canal from Bradford to join the Leeds and Liverpool Canal at Windhill in the township of Idle in the County of York." This country is, it is well known, far from favourable, topographically speaking, to canal undertakings. We lack the long level plains of certain Continental countries, and even in them, between competing points, the canal route is commonly 20 to 25 per cent. longer than the railway, owing to the relative closeness with which the latter can follow the natural contour of the ground.

Amongst the bills dealing with transport there may, perhaps, fairly be included the proposals for street improvements and widenings. Power for such works are sought by the local authorities at Burnley, Leicester, Leyton, Liverpool, South Shields and Wigan.

With regard to electrical matters we find that the only purely electrical bill promoted this year appears to be that in which the County of London Electric Supply Corporation seek powers for the erection of a new generating station at Barking. Two important hydro-electric proposals appear in the *Edinburgh Gazette*. One of these is a revival of the Lochaber scheme, which the House of Lords rejected two or three years ago on the plea that water powers should be developed by public authorities and not by private individuals, even when, as in this case, the latter had agreed to make substantial contributions to public funds in return for the privileges for which they asked. As was pointed out at the time, the plea on which the Peers acted would involve a delay of many decades in utilising the enormous energy now running to waste. Some 20 years ago the House of Commons rejected an electric power distribution scheme on the strength of strenuous asseverations that the municipalities and county councils were themselves ready and eager to do the work. The work, however, still remains to be done. It is to be hoped that next session the House of Lords may prove to have acquired a better knowledge of the history of industrial development, as cheap supplies of power are absolutely essential to the stability of certain highly important electro-metallurgical and electro-chemical industries. The company responsible for the Lochaber scheme propose to raise the water level in Loch Laggan, Loch Trieg and Idir Loch by dams, and to impound all the waters now flowing into the River Spey above its confluence with the Markie Burn; also the waters of the River Mashie and its tributaries; of the River Spean and its tributaries entering above its junction with the River Trieg, and also the waters of many minor streams now entering the River Spean or the River Lochy. The works will comprise a deviation of the North British Railway near the mile post indicating 79 miles from Craigendoran Junction. Works are to be erected in the parishes of Kilmallie and Kilmonivaig, on land bounded by the River Lochy, Loch Linnhe, the River Nevis and the West Highland Railway.

In another important power scheme it is proposed to use the gathering grounds of the Grampians in Perthshire. The works will involve the enlargement of Loch Ericht, Loch Pattack, Loch an t-Seilich, Loch Garry, Loch Loch-an-Duin and Loch Mhairc, whilst dams are also to be thrown across the Rivers Edendon Water, Allt Glas Choire, Allt Dearg, Allt-a-Mhuilinn, Allt-à-Chireachain, and the Bruar Water. Power stations are to be erected on the north shore of Loch Rannock, near Loch Ericht, Loch Cuaich, on the Bruar Water, and on the River Garry.

Turning now to water supply matters we find that the Metropolitan Water Board propose to make a new intake at Staines, near Penton Hook Lock, and to enlarge their No. 7 reservoir at Staines. Three new reservoirs are to be constructed at Hornsey, one near Walthamstowe and one near Sevenoaks. A considerable mileage of new mains is to be laid. Much of this will involve expensive street work, amongst the new mains included being one along the Edgware to the Marble Arch, and from Hampstead to John-street, Finsbury, with a branch to Islington and Theobalds-road. A clause in the Bill provides for the abolition of the office of water examiner. No doubt in the case of really large cities there is not the same necessity for independent control of the quality of the water supplied as is advisable in the case of the smaller boroughs. The experts employed by large communities have, in fact, sufficient standing to assert their independence, if the water authority refuses to attend to their requirements. Incidentally it may be noted that both the Conservancy of the Thames and that of the Lea are seeking powers to increase their charges for the water abstracted by the Metropolitan Board, and the latter in their turn are making arrangements for increasing rates. The Manchester Corporation seek power to divert some 7 miles of the route of the Haweswater Aqueduct as fixed in their Act of 1919. The Corporation of Preston propose to construct a weir across the Langden Brook, in Bowland Forest, and also across the Hareden Brook in the same area. A new reservoir is also to be made to the east of the existing Alston reservoir. The Batley Corporation propose to construct a new reservoir by damming the River Holme a little below their existing Ramsden reservoir.

The South Essex Waterworks Company propose to construct a new reservoir at Laindon Hills, together with a pumping station at Dagenham, and to enlarge their existing well at Romford. New pumping stations at Langham, and at Inworth, with new reservoirs at Langham and Danbury, are proposed by the Southend Waterworks Company, in conjunction with the South Essex Waterworks Company. The Burnley Corporation plan the construction of a new reservoir across the Cant Clough Beck, near their existing Cant Clough reservoir. The Nuneaton Corporation seek powers to construct a new service reservoir in their borough, and to purchase supplies from the Corporation of Leicester. The Sunderland and South Shields Water Company propose new pumping stations and wells at Hutton Henry and at New Winning with new service reservoirs at Mill Hill, Easington and Downhill. The Urban District Council of Million (Cumberland) seek powers to impound the waters of the Whicham Beck by a reservoir at Knottend.

The East Surrey Water Company propose to sink a new well at Smitham, and other work in the same area is proposed by the Sutton District Water Company, who are to construct a new service reservoir near Cheam and to sink a new well there, whilst the Croydon Corporation are to erect a new pumping station at Beddington. The Rotherham Corporation propose to make a new reservoir at Wickersley and to erect a pumping station at Bawtry. The Bristol Water Company have plans for a new service reservoir at Shirehampton. A new pumping station is also proposed by the water authority of Woodbridge. In Scotland a joint board for the supply of Falkirk and parts of Stirling propose new intakes from the Burnhouse Burn, and to enlarge Loch Coulter. Two new reservoirs are also to be constructed on the Earls Burn. The Town Council of the Bridge of Allan Water plan the enlargement of their Coxburn reservoir.

The Bills relating to harbour works are not numerous. The scheme for constructing a new deep-water wharf at Holehaven, Canvey Island, is again brought forward. Hitherto Parliament has taken the view that no scheme for improving Thames shipping facilities is to be considered on its merits, since the Port of London is now controlled by a public authority, from which alone will proposals for betterment be accepted. The backers of the Holehaven scheme have presumable reasons for believing that Parliament will not continue indefinitely to reject important improvements simply because they may affect existing interests adversely. A new company proposes the improvement of Dartmouth by the construction of new quays at Kingswear, and by dredging the River Dart.

Much new work is proposed at Peterhead Harbour. The existing Port Henry Pier is to be extended by 30 ft., and two new jetties built, one 240 ft. long and the other 300 ft. long. The portion of the outer basin of the North Harbour included between these two jetties will be deepened, as will the inner basin of Port Henry and the South Entrance Channel. A considerable length of new quay will be built and the works contemplated include two new opening bridges. The Trustees for Rothesay Harbour seek powers to extend the harbour wall by 210 ft. and the Albert Pier by 100 ft.

The applications to Parliament made by gas undertakers are numerous, but they are almost wholly devoid of general interest. For the most part, the Bills lodged have to deal with the establishment of a calorific standard for gas. The charge proposed per therm varies greatly, ranging from 1*s.* 1½*d.* up to 2*s.*, and it is not in a fixed ratio to the price hitherto paid per 1,000 cub. ft. As far as we have ascertained, the only novelty appears to be a proposal of the Batley Corporation to manufacture and supply a special fuel gas for industrial purposes.

THE CYCLE AND MOTOR-CYCLE SHOW.

WHILE the exhibition of cycles and motor-cycles at Olympia, which opened on the 29th ult., does not indicate any great tendency to novelty it is very interesting as showing examples of an extremely specialised type of engineering. Although the ordinary push bicycle is a very small and relatively simple machine in itself it has had an effect on the world's social life greater than that of many machines which have attracted the attention of engineers to a far greater extent. Further, it was the forerunner of the motor-cycle, which has had still more revolutionary effects, for it was in connection with the motor-cycle far more than in the early motor car that the principles of the high-speed petrol engine were worked out, and this has not only

revolutionised road transport but also led to great developments in flight.

The cycle and motor-cycle are also interesting in that their development has been almost entirely by rule of thumb. It is probably seldom that any calculations of stress, &c., are made in either of these branches. There are no doubt many advantages in the method of direct trial and error in place of calculations, which are after all the result of formulæ based on trial and error, in cases where it is possible to carry out that method of acquiring data on a large enough scale. It is unfortunately not practicable to build a large number of Atlantic liners, let us say, in order to experiment as to how light they can be built without risk, but there is no doubt that if such experiments could be tried progress would be more rapid than it has been. Such experiments are, however, quite possible in the case of cycles, and accordingly it is generally simpler to carry out actual experiments than to make calculations based on imperfect data.

Accordingly the ordinary push cycle is now a very perfect machine, very light indeed in proportion to the weight it carries and yet giving very little trouble. Theoretically its defect is that the frame is very imperfectly trussed. Fig. 1 shows the ordinary frame in full lines, while the dotted lines show an addition which ought theoretically to very much improve the trussing and make the frame stronger and lighter. Yet although this and other arrangements have been tried the ordinary frame holds the field. The possible reason for this is that a bicycle frame has to have a considerable resistance to torsion, and it appears likely that if the ordinary frame is made rigid enough in this direction the bending stresses on the joints due to imperfect trussing are not of serious importance. At all events the frame of the ordinary construction can be made satisfactory with a weight of some 6 lb., and therefore the margin for saving weight by improved construction is very small.

The ordinary push bicycle having now become a standard production, there are naturally no real novelties at the show and the greater interest therefore attaches to the motor-cycle section. The problem of making a really satisfactory motor-cycle, looking at the matter from an engineering point of view, is by no means an easy one. In a motor-cycle it is impracticable to protect the engine from the weather in the way it is protected in a car, while there are very distinct limitations in the way of weight and space. In particular the whole of the machinery has to be got into a very narrow space so as not to foul the rider's legs. Owing to questions of cost, and complication, the one or two-cylinder engine is practically universal, and a considerable part of the weight of such engines is flywheel. This makes it very essential to run the engines very fast to keep the weight down, while on the other hand they have to run with very unskilled attention, as few motor cyclists keep a chauffeur, and many of them have very little time to attend to their machines themselves. Water cooling, again, is not general on account of weight and cost, and the engines must therefore be designed to run with air cooling.

When all these points are considered it will be acknowledged that the problem is, as we have already stated, by no means an easy one to deal with, but it has been very largely solved by the same process as that used in the evolution of the push-cycle, namely, trial and error. The result is that the motor cycle is now a very satisfactory machine, though it can hardly be said to have reached the same state of perfection as the push-cycle, and there is little doubt that it is capable of a considerable amount of improvement. In fact, it appears as if the motor-cycle has now reached a stage where a real scientific investigation of its construction might produce excellent results. The conventional motor-cycle of the present day is constructed very much on lines developed from the push-cycle, but modified to suit the new conditions. The framing is of steel tube brazed into lugs of cast malleable or steel —usually the former—and follows the general lines of the push-cycle, and is usually just as devoid of scientific trussing. The riding position is, of course, entirely different, the saddle being some 10 in. lower and the outline of the frame is modified accordingly. A vertical single cylinder engine is mounted on the bottom of the frame, while a three-speed gear-box is mounted below the frame and behind the engine. This is driven from the crank-shaft by a chain, and there is a friction clutch in the chain-wheel. In order to allow for this chain stretching the gear-box slides bodily on the frame and the chain can therefore be adjusted by shifting the gear-box. From the gear-box the back wheel is driven by either a belt or a chain. In the latter case the back wheel slides in forks to adjust the back chain.

While the single-cylindered engine is in the majority a large number have diagonal two-cylinder engines with two connecting rods working on to one crank-pin, the general arrangement being otherwise the same. In the majority of cases the flywheels are inside the crank-case and the crank is of the built-up type, though in some cases forged cranks and outside flywheels are used. This conventional type of machine has been very satisfactory in practice, but appears to be open to considerable improvement.

Fig. 1.

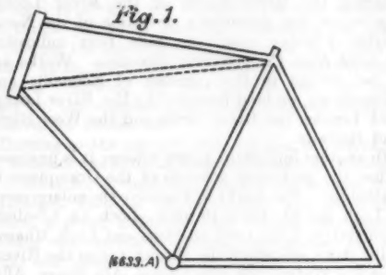
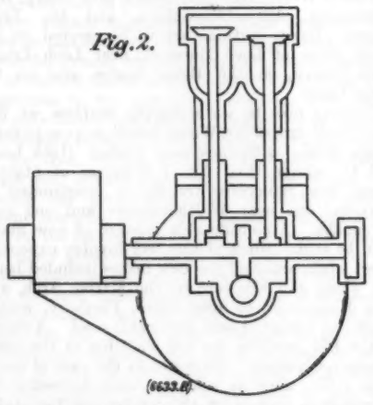


Fig. 2.



Probably one point which has tended to make it come into general use is the fact that it lends itself to the convenient construction of an "assembled" machine. Thus engines and gear boxes are made as specialities by various firms, as also are hubs, front forks, &c. This makes it easy to assemble a motor cycle without making these parts, but it is doubtful whether this is the best method of production. It is far more important that any machine should be a harmonious whole than that the individual parts should be good, and therefore it is probably better to have that whole designed by one person rather than to be an assemblage of specialities.

Taking the conventional design in detail, the engines are on the whole generally satisfactory, though it appears that a four-cylinder engine should be an improvement for the high powers and a twin for the lower ones. The greater the number of cylinders the lighter the flywheel for a given power, and the flywheel forms a great part of the weight of the engine in engines with few cylinders. Where they are in the crank-case large flywheels also mean a heavy crank-case. Some makers accordingly put the flywheels outside, but there are some distinct advantages attending the inside position. In the latter case the wheels are directly connected to the crank-pin and both the compression pressure and driving impulse come directly on them and have not to be transmitted through a portion of the shaft and one of the main bearings. Probably these advantages outweigh the savings of weight obtained by putting the flywheel outside.

The greatest defect in the ordinary design of engines appears to be the great number of gear wheels, levers, &c. There are usually two gear wheels and camshafts for the valve gear, and even then rocking levers are often used to drive the valves while, in addition to this, a chain or train of gear wheels is often used to drive the magneto. While the restricted width and the large diameter of the inside flywheels prevents the use of the simple arrangement usual in a car it should be possible to materially simplify the arrangements now generally adopted. Some years ago a motor-cycle was shown with a single-cylinder engine having a longitudinal camshaft on one side driven by skew gear from the crankshaft. The valves were at the sides in the ordinary way, vertically over this shaft and the magneto was at one end of it and the oil pump at the other. There were therefore only two gear wheels in the whole engine, in place of the usual four or more, while the tappets were driven direct without levers. This arrangement is shown diagrammatically in Fig. 2. There are attempts in some engines shown at reduction in parts, but none so simple as this.

Lubrication is still by plain splash as a rule. While this has worked well, if properly attended to, it seems that some better method should be possible, as many riders either over or under-lubricate their engines. In some cases pumps are used to introduce the oil into the crank-case, and in this case the feed is far more uniform. A sump with a trough under the big end should, however, be more satisfactory, and no more expensive, as the separate oil tank and pipes would be done away with.

The general arrangement of the transmission seems open to great improvement. As the gear-box is separate from the engine, the frame must be very rigid, and therefore heavy to prevent the stress on the chain pulling it out of line. Also there must be an adjustment for the chain. The engine being fixed, the gear-box must be arranged to slide for the adjustment. This means that adjusting the front chain throws the back one out of adjustment and makes the complete adjustment a troublesome matter.

It appears high time that motor-cycle makers followed the example of car makers and combined their engines and gear-boxes in one unit. The front chain could then be run in an oil bath, and would be so short that it should need no adjustment. Alternatively, gear could be used as is done in the case of two American machines which have combined engines and gear-boxes. The unit would be distinctly lighter than the separate engine and gear-box, while the frame could be lightened very perceptibly. There are a few machines in which the engine and gear-box are so combined, but it is desirable that the practice should extend very considerably.

In the matter of frames there appears to be room for very great improvement. The ordinary push bicycle has, as mentioned, got to very satisfactory proportions in this matter, as the result of trial and error. Now the result of this trial and error is that in the cycle 1 in. or 1⅛ in. tubing is usually used for the main tubes, the thickness varying slightly according to the use the machine is to be put to, but being usually $\frac{1}{16}$ in. or less. Theoretically in making frames of varying strengths and weights, both diameter and thickness should be varied, the proportion between the two being constant, but from manufacturing reasons it is desirable to keep the diameter constant and vary the thickness so as to have standard lugs. Theoretically, also, the larger the diameter of a tube, and the thinner it is made, the stronger it is for a given weight, but there is a limit beyond which it is undesirable to go on account of the want of local strength. By trial of various diameters of tube, from under ⅞ in. to over 1¼ in., it was found that 1 in. or 1⅛ in. gave the best results on a push bicycle.

Now if the motor cycles are examined it will be seen that the diameter of tubing is little, if any, greater in their frames than on those of the push bicycles. The motor-cycle is, of course, enormously heavier, and also goes at far higher speed, hence the stresses on the frames are very much greater.

Accordingly the tubes are made a great deal thicker, in many cases nearly ¼ in. thick. Even then, however, frame breakage was very common in France during the war, and it is evident that the frames have barely the proper margin of safety. It appears that what is wanted is not to make the tubes thicker but of much greater diameter. If a certain proportion of diameter to thickness is right for a push cycle, approximately the same proportion should be right for a motor-cycle, and it is obviously hopelessly wrong to make the tubes the same diameter and simply get strength by increasing the thickness. This appears to be a case where the trial and error method of the cycle maker might be greatly improved on.

In the matter of weight there also seems room for improvement. The motor-cycle, like the motor-car, has grown in weight considerably during the last few years. This seems progress in the wrong direction, for the essential requirement of a cycle is that it should be light. In some cases this increase in weight is due to greater elaboration, as, for instance, when a complete lighting set is fitted, but apart from these things there still appears to be an increase. It is time that a really careful study was made of the weights all round, to see whether they cannot at all events be got down to that of the older machines.

Among the departures from the conventional type are some which have been on the market for a considerable time, others quite new. Among the former are those fitted with the horizontal twin-engine in place of the vertical. This type has undoubted advantages, being almost perfectly balanced and having the impulses evenly divided. It practically entails a forged crank and outside flywheel, and takes up rather a greater length in the frame in the larger sizes. It is apparently a distinctly more expensive engine to build, but apart from this appears to have a balance of advantages in its favour, and it is interesting to see that there are several new examples of this type.

Spring front forks are universal, but springs to the back of the frame are still unusual, though a certain number have been on the market for years. There is no doubt as to the extra comfort due to them, and they also save the machinery from the road shocks, but they certainly entail slightly greater weight and expense. Probably on the lower powered machines they are not worth while, but on the large ones they should become universal.

The majority of the engines are of the ordinary four-stroke type, but among the smaller sizes there is a tendency to adopt the two-stroke. On the whole, the four-stroke is probably the best type for general purposes, but the two-stroke has the advantage of being a great deal the cheapest to produce, as well as being very simple, and this is of importance in the smaller sizes. The two stroke engines shown are all of the ordinary type in which the crank-case is used as a compression chamber for the charge before delivery to the cylinder.

While the belt or chain hold the field as a means of transmission to the back wheel, the "F.N.," shown by Messrs. F. N. (England), Ltd, Kimberley-road, Willesden-lane, London, N.W., is an interesting example of shaft drive. Two types are shown, and both have the engine placed with the crankshaft longitudinally, a clutch and sliding gear gear-box, a shaft drive and bevel gear to the back axle. In fact, the whole lay-out is similar to the ordinary car. The smaller size shown has a single cylinder, while the larger gets very close to the car practice, having a four-cylinder engine. There are certain very distinct advantages in the shaft drive, but this appears to be practically the only example which remains in the market.

As mentioned, there is a tendency to fit the motor-cycle with electric light. Accordingly a considerable amount of interest attaches to the efforts of certain magneto makers to use the spare current from the magneto for this purpose. It is quite wrong theoretically to have two electric generators on a vehicle, one for the lighting and the other for the ignition, and this has led the American car makers to use the lighting generator to supply current for the ignition. In the ordinary motor-cycle the opposite seems to be likely to take place as the current on the idle strokes of the magneto may be used to charge a battery and light the lamps. At least two examples of magnetos which will charge batteries on this principle are shown.

Apart from the ordinary motor-cycle there are two interesting developments. The first is the cycle car designed to take the place of the motor-cycle and side car. The latter is immensely popular, yet from a mechanical point of view it is hopelessly defective. It is obvious that if the ordinary "combination" were built as a passenger unit without the idea of the bicycle part ever being used alone, the machinery could be very considerably simplified and cheapened, as well as being made far more satisfactory. The whole object of the designer of the motor-cycle is to keep the machinery within the width of the rider's feet, and this entails a great deal of complication and expense. If it were not for this limitation of width the gear-box could be placed in line with the engine, magneto on the crank shaft or camshaft, &c., and the whole design very much improved and also cheapened. Further, if the machine were designed as a combination pure and simple the framing should be very much simpler. Two longitudinals and three cross-pieces are ample for the frames of a car, so the numerous bits usual in a side-car combination cannot be necessary. From the point of view of the user, the comfort of the machine could be greatly improved if the passengers sat side by side on a seat in place of one on a cycle saddle and one in the side car.

Accordingly there have been numerous attempts to make a "cycle car" which would take the place of the cycle and side car. Several of these are exhibited at the present show. So far none of them seem quite to have come up to the requirements of the situation, for the side car is still shown in very large numbers in many cases on cycles of such weight that they are not likely to be much used alone.

Probably there are two reasons for the predominance of the side car, the one mechanical, the other commercial. Few of the "cycle cars" appear to have been designed with enough consideration of the requirements of the case to be thoroughly satisfactory. In order to meet the demands for cheapness in first cost and running, both the manufacturing cost and weight must be very carefully considered in the design. Framing, engine, transmission, &c., must be reduced to the very fewest number of parts. Unfortunately, this is not by any means always the case, the designs often being far more complicated than necessary. One attempt in this direction, for instance, has over 40 pieces in the frame, as compared with five for a full-sized car.

The majority of the machines of this type have a single driving wheel at the back and two steering wheels. The engine is usually placed in front, as in a car, and there is a gear-box of the usual type with either shaft or chain final drive. There seems no doubt that a machine of this type could be made far more efficient than the cycle and side car if really carefully-designed, but most of those shown seem, as we have said, capable of much improvement.

On commercial grounds any machine of this type would have to be very sound to drive out the cycle and side car, as the latter has the advantage of using a great many parts which are usual in the motor cycle, and can therefore be made in great quantity. Also the buying public may expect a great deal more of any vehicle which calls itself a car than they do of the vehicle which calls itself a cycle, and this may very much affect sales.

The other variety of machine which is of interest is the vehicle which is intended to come between the push cycle and the ordinary motor-cycle. The latter has gradually increased in weight till it weighs some 180 lb. minimum. True, even the small machine is powerful and fast, but there are many people who want to be propelled but who do not want to go very fast, and equally don't want to have to handle a heavy weight. Another point is that in the ordinary motor-cycle the engine is placed between the rider's legs. This is of no importance when going on a long journey, and is the best place from a mechanical point of view. It usually means, however, that special clothes have to be worn, as oil from the engine is liable to get on to the rider's legs, and this is frequently a great disadvantage. Accordingly many varieties have been produced. These fall into two categories. First there is the attachment intended to be fixed to the ordinary cycle, and, second, the "motor scooter." The former can only be successful if it does not entail putting any additional weight on the frame of the machine, for the ordinary cycle is not built with a great margin of weight. Several examples are shown, one of which we illustrate on page 735 of the present issue.

The motor scooter is usually a motor-cycle with a small engine and very small wheels, generally about 16 in. Originally it appears that the rider was expected to stand on footboard as a child does on a scooter, but most are now provided with saddles. While these machines may be a convenience to some, the small wheels must be a very great disadvantage, and the mechanical arrangements usually are not so good as the ordinary motor cycle.

Taking it all round it seems that the interests of those who want something a great deal lighter than the ordinary motor cycle would be best served by a well-thought-out machine of the ordinary type, but of light weight, with the engine very carefully designed not to throw out oil. In designing such a machine only a low power and moderate speed should be aimed at, and two speeds would be ample, possibly a single speed enough. The petrol tank need not carry fuel for long runs, as the machine would be essentially intended for short-distances. Granting these conditions, it should be possible to get a useful motor-cycle down to 100 lb., and yet to make a machine better than either the attachment to the ordinary cycle or the motor scooter.

One very striking feature of the show is the very small number of foreign exhibits. In the Motor Car Show and the Commercial Vehicle Show there were quite a large number of foreign vehicles, especially in the former case. In the motor-Cycle Show, however, there are hardly any Continental machines,, though there are a few, such as the "F.N.," which hails from Belgium. There are also a few examples of motor cycles from America, but the very large majority of the cycles and motor-cycles are British.

NOTES.

INDUSTRIAL ELECTRICAL RESEARCH.

ENGINEERING in its various branches has not so far figured very prominently in connection with the formation of research associations under the scheme operated by the Department of Scientific and Industrial Research, but an important association has now been inaugurated for dealing with electrical matters. The comparatively little activity which has been displayed by the engineering trades in this matter is no doubt partly attributable to research and investigation, in many forms and in many places, having long been an everyday matter with engineers and engineering manufacturers, while in some of the trades which have taken advantage of the Government scheme research of any kind appears to have been previously unknown. That this State-assisted scheme, while valuable, opens no new vista to the engineering trades is illustrated by the fact that this recently-formed electrical association does not cover new ground, but is to carry on work previously covered by a research committee of the Institution of Electrical Engineers in conjunction with the British Electrical and Allied Manufacturers' Association. The new association, which is incorporated under the Department of Scientific and Industrial Research, has been constituted by the two bodies mentioned, and bears the title of "The British Electrical and Allied Industries Research Association." The new organisation has a guaranteed minimum income of 16,000*l.* a year for five years, half of this sum under the Government scheme being contributed from State funds. There is no reason to suppose that the work previously carried on will be interfered with in any way by the official connection which has now been established, and the extra income will be of much value in enlarging the possible scope of the work carried out. The matters at present in hand cover an investigation on the sludging of insulating oils,

the preparation of standard specifications for insulating materials, and a research on the heating of buried cables. A preliminary report on this latter investigation has already been prepared, and is to be discussed at forthcoming meetings of the Institution of Electrical Engineers. Other matters in hand include investigation of composite and fibrous insulating materials, porcelain, mica, &c., and a research in connection with mining switchgear. Mr. E. B. Wedmore is the secretary of the Association and Director of Research, and the offices are at 19, Tothill-street, Westminster.

Discussions at Institution Meetings.

On leaving the meeting of the Institute of Transport on Monday last we confess to a feeling of considerable disappointment. Here is a practically brand new institution, capable of attracting very good attendances at its meetings, but apparently quite unable to stimulate anything in the way of discussion. Owing to its short existence it is perfectly impossible that the views of all the members should be known to each other, yet on Monday last only four speakers had anything at all to say on the paper read, three of them from places at the council table and only one from the body of the hall. We hope that everything possible will be done to change such a state of affairs. The Institute has had a good send-off, and has plenty of influential support, but it will not succeed in life unless it fosters debate. Members will not for long attend the meetings merely to listen to papers which they can read equally well in greater comfort a few weeks later from their journal. If an interesting discussion may as a rule be anticipated, the attendance will, on the other hand, probably increase. We may suggest that a little tactful stage management would help to break the ice, and assist many, who perhaps feel that they are as yet among comparative strangers, to understand that their co-operation is sincerely desired in these matters. A little care, however, is needed in this direction. We were recently at a meeting at which those responsible for this sort of thing had been almost too successful in their efforts. The room had apparently been filled with invited experts, and the ordinary member and casual speaker could not get a look in, though evidently several were anxious to contribute some remarks. If it is overdone in this way the last state may well be worse than the first, as keen men inside the Institution will not attend if they find themselves cut out from all participation in the proceedings. There is no fear of such a state at present, it appears, at the Institute of Transport. The subject taken on Monday last was "Economics and Co-ordination of Transport by Road," which is wide enough in all conscience. Although Mr. Shrapnell Smith's paper suffered perhaps from being rather too comprehensive, it must be allowed that it furnished endless points for discussion, ranging from taxes to fuel supply, and from labour troubles to clearing houses. We offer the opinion for what it is worth, that a good discussion warms the heart of the author of a paper much more than honeyed words of congratulation and thanks. There is no doubt whatever as to which is of more value to the progress of the community.

Electricity Supply in London.

It is matter for satisfaction that there now appears a likelihood of a Joint Electricity Authority for the London area being constituted by fairly general agreement. In view of the position which the London County Council has taken up on more than one occasion on this matter of electricity supply, it would have been no surprise if it had raised difficulties in connection with the formation of a joint authority. The recommendations of its Special Committee which has been appointed to inquire into the matter were, however, accepted with but little comment at the Council meeting last Tuesday, and the formation of a joint authority would now appear likely to go through without opposition from the Council. The Council have apparently been brought into close touch with both the other local authorities concerned and with many of the principal London supply companies in connection with the fairly general opposition which was offered to the proposal of the County of London Electric Supply Company to build a large station at Barking. It is, however, recognised that, particularly on the financial and administrative side, there may not be uniformity in the ideas of the Council and those of the other local authorities, and the companies and the Council propose themselves to prepare a scheme for a joint authority for submission to the Electricity Commissioners. In drawing up its details, however, they propose to keep in close touch at least with the other local authorities. The technical details of the Council scheme are being worked out by Mr. J. H. Rider, and before the scheme is completed and ready to go before the Electricity Commissioners no purpose would be served by discussing it narrowly. It is interesting to note, however, that the Council have realised the time not to be a fit one for sweeping schemes of purchase. They think, and we concur, that "any arrangement which involved the immediate acquisition of the whole of the generation and transmission side of electricity supply in the area would handicap the authority." They are accordingly to propose that all new stations, generating plant and transmission lines should be provided by the authority, but existing plant, stations and distributing systems should remain in their present hands. It is intended that by this system all generating plant should ultimately become the property of the Joint Authority. When this process is complete it is proposed that stations and transmission lines should be purchased on a basis of original cost less depreciation. This latter proposal is clearly likely to meet with opposition from the companies, and in any case the matter cannot be divorced from the rights of the companies to be bought out in 1931, under the terms of the Electric Lighting Act of 1888. The actual meaning of the purchase terms of this Act are, we believe, still to be determined in a Court of Law.

INDUSTRIAL NOTES.

The Ministry of Labour state that the decline in employment, which was observed during September, continued in October. In the latter half of the month most of the principal industries were seriously affected by the shortage of fuel resulting from the general strike at the coal mines, and at the end of October employment in most of these industries was very slack. The proportion unemployed among members of trade unions (mostly of skilled workmen) from which returns are received rose from 2·2 per cent. at the end of September to 5·3 per cent. at the end of October, and the number of workpeople claiming out-of-work benefit under the Unemployment Insurance Acts of 1911 and 1916, or the out-of-work donation scheme for ex-service men, rose from 274,000 to approximately 500,000. In addition, large numbers of workpeople in many of the principal industries were on short time at the end of the month.

The total number of trade disputes, involving stoppages of work, reported to the Department as beginning in October, was 71. In addition, 93 disputes which began before October were still in progress at the beginning of the month. By far the most important of these disputes was that involving about 1,100,000 workpeople in the coal-mining industry—which began on October 18 and continued into November. The total number of workpeople involved in all the disputes in progress during October (including those thrown out of work at the establishments where the disputes occurred, though not themselves parties to the disputes) was about 1,200,000, as compared with 104,000 in the previous month and 630,000 in October, 1919, when disputes were in progress involving 500,000 railway workers and between 60,000 and 70,000 iron-founders, coremakers, dressers, &c. The estimated aggregate duration of all disputes in the month was about 13,474,000 working days, as compared with 1,109,000 in September, 1920, and 4,670,000 in October, 1919.

In the industries for which statistics are available changes in the rates of wages reported to the department as having been arranged to come into operation in October resulted in a total increase of over 118,000*l.* in the weekly wages of over 780,000 workpeople. The principal bodies of workpeople affected were those employed in the railway service, among whom adult men engaged in the manipulation of traffic received an advance, under the sliding scale, of 2*s.* a week, and male clerks, supervisory staffs and traffic control staffs received advances of 4*s.* a week, or 10*l.* per annum. Other important bodies affected were workpeople in the brick, tile, &c., and cement trades, and vehicle builders and wheelwrights.

The average level of retail prices (including those of food, clothing, fuel and light, &c., as well as rents) at November 1, as indicated by the statistics prepared by the Ministry of Labour, was about 176 per cent. above that of July, 1914, as compared with 164 per cent. at October 1. The increase was mainly due to the increase in the retail prices of flour and bread following the reduction of the subsidy, but part, also, to increases in the prices of butter, milk and eggs. On the other hand, reductions in the prices of some articles of clothing were reported by many retailers. The statistics are designed to indicate the average increase in the cost of maintaining unchanged the average pre-war standard of living of the working classes. Accordingly, in making the calculations the changes in the prices of the various items included are combined in proportions corresponding with the relative importance of those items in pre-war working-class expenditure, no allowance being made for any changes in the standard of living.

In the eighty-fourth quarterly balance-sheet of the General Federation of Trade Unions, the secretary, Mr. W. A. Appleton, states that no one can contemplate the industrial situation without grave misgiving; reports concerning unemployment, both actual and prospective, are serious enough to make every man who has experience very anxious. Many thousands of good workers are facing the winter with fear. To discover the real causes of unemployment and the real remedies would be worth all the money the trade union movement possesses. It is no use talking about the right to work unless we can discover the laws that govern work and the proper way of applying them. Many believe that heavy taxation and adverse rates of exchange are responsible for much of the trouble that afflicts Britain. Others place the major portion of the blame upon the Departmental interferences and upon the uncertainty which exists in connection with delivery and price. It is also said that, compared with pre-war, from three to four times the capital is required to start or to expand a business. With the rate of interest at 8 per cent., commencing or expanding a business is an exceedingly difficult operation. With the lack of new capital at reasonable rates the question of the utilisation to the full of the existing capital, whether it is fluid or fixed, becomes a matter of vital importance. In studying this subject it is necessary to disregard preconception, and to get at and act upon the truth. If we do this it may be that we shall find that the artificial obstacles to exchange which the different nations are setting up, though not the main cause of unemployment, are at least an adverse influence. It may also be found that prices have passed beyond the capacity or the willingness of the potential buyer. Whatever the causes we ought to state them. If we can do this we may not only relieve present distresses but prevent them in the future.

Mr. Appleton also states that the membership of the Federation continues to increase, and now stands at a total of 1,633,230. The contributions also show an upward tendency. In 1907 they totalled 25,656*l.* for the year; in 1920 they total 25,649*l.* for one quarter. In 1907 the Federation paid in dispute benefit 8,467*l.*; the quarterly average for the present calendar year amounts to 13,403*l.*

The Joint Committee of the Mining Association of Great Britain, representing the coalowners, and the Miners' Federation, representing the men, held a conference in London last week, at the close of which the following statement was made:—

"A friendly discussion took place on the consolidation of present wages, and the future regulation of wages in the industry. The question of output was also considered, and the following resolution was passed: 'To ask the district committees to forward each week, with the least possible delay, to the National Committee, statistical information as to the aggregate output of the collieries in their respective areas each calendar week, *i.e.*, from Monday to Saturday, in order to keep the committee informed as to the movement of output. Such information to be accompanied by a report indicating whether or not, in their opinion, the output is satisfactory, or, if not, what they consider to be the cause. Such statistical information should set out the weekly output per person, (*a*) for getters and fillers; (*b*) total number of persons employed underground; (*c*) total number of persons both underground and on the surface of the mine.'"

The meeting was adjourned to a later date.

The Halifax Corporation Tramways Committee have passed a resolution declaring that the frequent applications from trade unions for increases in rates of pay are prejudicial to the interests of the municipality, and that until a National Joint Industrial Council, controlling all classes of labour connected with municipalities is established, the inconsistencies

at present existing will continue. The resolution adds that the time has arrived when a National Joint Industrial Council, dealing with all classes of labour, should be established, and the many Joint Industrial Councils abolished. The committee further declare that the cycle of wage advances does not benefit employees, and that attempts should be made to reduce the cost of living.

Speaking at the Stephenson Memorial Hall, Chesterfield, last Sunday, Mr. J. R. Clynes, M.P., admitted that the Labour Party had its faults, and the chief fault was of its own making, namely, impatience. There was a desire to make headway too quickly, and nine or ten sections had been formed, with the result that not only was there an internal weakening of the Party, but the public were bewildered and scarcely knew what Labour stood for. There was within the ranks of Labour a lack of that toleration and charity without which no movement could prosper.

After the launch in the Mersey last Saturday of the Cunard steamer Samaria, built by Messrs. Cammell Laird and Co., Limited, Sir William Forwood, a director of the company, stated that he was giving away no secret when he said the Samaria ought to have been launched and in commission six months ago. This was because labour, although they took pay for 8 hours' work a day, only worked 5½ hours or 6 hours a day, and the ship had cost probably 250,000*l.* more than she ought to have done. Labour was short-sighted, for had they worked as in pre-war times the ship would have been cleared and her berth occupied by another vessel. There were thousands of men walking the streets of Birkenhead, and he trusted wiser counsels would prevail. Sir George Carter, the managing director of Messrs. Cammell Laird, said it was difficult to recognise labour to-day as being organised. The Shipwrights' strike stopped all repair work in the river, and thousands of men were thrown out of work. That strike took place without the authority of the executive, and the men thought of nobody but themselves. That was not organised labour, and until it was properly organised it was impossible for any industry in the country to go on as they had a right to expect.

The third quarterly report, from June 28 to September 25, of the Associated Blacksmiths' and Ironworkers' Society, records an increase in the membership. The figure at the close of September was 23,310, an increase of 153. New branches have been opened at Fleetwood, Falmouth and Coalburn, making the total number of branches 201. The income for the quarter is returned as 14,839*l.*, a reduction on that of the June quarter of 2,460*l.* The expenditure for the quarter amounts to 14,010*l.*, an increase over last quarter of 2,990*l.*, and accounted for by a general increase in the expenditure for unemployment, dispute, disablement, accident and superannuation benefits, together with the increase of the affiliation fees to the Labour Party and Trade Union Congress, and the extraordinary call of the Engineering and Shipbuilding Trades' Federation.

The Railwaymen's International Congress opened in London last Monday; it was attended by representatives of 1,357,000 workers of this country, France, Belgium, Holland, Sweden, Denmark, Luxemburg, Austria and Germany. Mr. J. H. Thomas, M.P., stated he believed there would be a big fight in the next few months in this country. It would take place over a new stand the railwaymen were going to make. "We have fought for hours and wages," said Mr. Thomas, "and we have succeeded in reducing our hours and increasing our wages. We believe we can contribute something to efficient railway management. We believe the railwaymen can, by their experience, do much to help to improve our transport system. We believe that where there are problems on the managerial side it would be better if we knew all about them, but we are denied that opportunity. Only a few years ago railway companies said that our business was merely to do what we were told. We answered that by saying, when the Government a few months ago indicated in their White Paper that they realised the railwaymen ought to share in the management, that it was our intention to hold the Government to that promise and to see it was not camouflage for the purpose of bluffing the public. I hope our Government will understand clearly that on this matter the railwaymen of our country are absolutely united and determined."

According to *The Yorkshire Post*, Mr. J. T. Brownlie (Amalgamated Engineers' Union), speaking at a meeting of engineers at Gainsborough last Sunday, warned trade unionists not to be led away by the wild vapourings of extremists. If it was wrong for a Government to plunge a nation into war, it was equally wrong for the working classes of this nation to throw themselves into suffering through the extremists' policy. He was, he added, a democrat, and believed in democracy, but he was very much afraid of a proletariat Government, because he knew something of the dictatorship in Russia. They were not going to destroy capitalism by asking for more wages, and if they were driven to a policy of direct action he foreshadowed a considerable amount of suffering which would fall upon the working people. We should be starved out in the course of a few weeks because we were dependent for five-sixths of our foodstuffs on foreign nations, who would cease to supply us because our credit would be shattered.

The shipyard joiners and carpenters having been informed that the special bonus of 12*s.* per week which was granted them in April last is now to cease, large numbers of these craftsmen have come out on strike.

"LIMIT GAUGES."

TO THE EDITOR OF ENGINEERING.

SIR,—In your interesting leader on "Limit Gauges," in your issue of the 12th ult., you mention the fact that at the beginning of the war Woolwich insisted on "not-go" screw gauges, but hardly give to Sir Richard Glazebrook the great credit due to him for their abolition. As "Director of Production" to the Ministry of Munitions in its early days, I had to deal with gauge production, and of all one's work the question of production of screw gauges was easily the most difficult. By Sir Richard Glazebrook's suggestion and influence the "not-go" gauge was abolished, and not only was our work on screw gauges halved and thus rendered practical, but, as I have often said, the country saved many times over the whole cost of the National Physical Laboratory since its inception. This institution must ever remain a monument to Sir Richard, and one shudders to think what would have been our position had it not been for the great work its gauge department was able to carry out during the war, owing to his foresight. Its very existence was due to his pertinacity and business acumen as well as scientific knowledge, and only by a true history of those troublous times in the second half of 1915 can we realise what we owe to him.

There is only one other point, and that is to state that Mr. Turner, referred to as "of the National Physical Laboratory," was I believe, when working with Mr. Taylor, in the employ of one of our railway companies, although attached to the Ministry of Munitions and allocated to the Laboratory.

Yours faithfully,
HY. FOWLER.

Derby, November 25, 1920.

ON THE INFLUENCE OF GASES ON GROWTH OF CAST-IRON UNDER REPEATED HEATING CONDITIONS, &c.

TO THE EDITOR OF ENGINEERING.

SIR,—Your reference, in the issue of November 26, to the recent work of Messrs. Okôchi and Satô, of the Tokyo College of Engineering, is of interest to all students of the metallurgy of cast-iron. The careful and clearly summarised researches of our fellow metallurgists in Japan on the subject of cast-iron shows that they are advancing rapidly in practical research.

The writer would call attention to the recent paper of Messrs. Honda and Marakui (Iron and Steel Institute, September, 1920) on the graphitisation of iron-carbon alloys, wherein the authors give strong reasons for their conclusion that the mechanism of graphite formation in such alloys is due to the influence of the gas CO imprisoned within the metal—either in solution or in the free state.

It was shown that there occur at about 1,130 C. reactions of the type:

$$2\,CO = CO_2 + C \quad . \quad . \quad . \quad (1)$$

and

$$CO_2 + Fe_3C = 2\,CO + 3\,Fe \quad . \quad . \quad (2)$$

so long as there is an appreciable quantity of CO gas left in the metal. It will be noticed that this action occurs during the volumetric expansion of the cast-iron at about the eutectic freezing-point, as first clearly indicated by Professor Turner in his valuable research on volume changes in cast-iron.

The inference is that gases play a very considerable part in these volume changes. The important function played by imprisoned gases in the phenomena connected with dilatation at the allotropic change or recalescence points is now proved by Messrs. Okôchi and Satô, who have shown that the included gases are the chief cause of growth in grey cast-iron when repeatedly heated above the Ac_1 point.

It may be of interest to state that the work of our fellow metallurgists in Japan confirms the results of similar researches on the same subject conducted between the years 1902 and 1907 by the writer. In a paper on the "Influence of Gases on the Structure of Cast-Iron and Steel," read before the Staffordshire Iron and Steel Institute in 1907, the writer gave reasons for his conclusions that the dilatations which accompany the allotropic changes occurring during the heating of iron and steel are largely due to the presence of gases imprisoned within the metal masses.

Professor H. C. H. Carpenter proved later that included gases influence the growth of repeatedly-heated cast-iron, but he did not specially define such influence as related to the phenomenon of dilatation at the point of maximum dilatation, Ac_1.

The writer would like to emphasise the imprisoned-gas influence further in considering the problem of puddled iron manufacture.

He has recently shown (paper on "Future Developments in Puddled Iron Manufacture," Staffordshire Iron and Steel Institute, 1919) that when grey cast-iron is melted in the puddling furnace refining actions proceed in the liquid metal until a carbon content of, say, 2 per cent. is reached. Below this point the furnace temperature is too low for further refining in the liquid state, and the plastic iron crystals begin to separate out (helped by the agitation of the puddler's rabble) from the liquid eutectiferous matrix which becomes the *locale* of the CO and other gases expelled from the congealing iron crystals as they "come to nature."

The resulting ball of spongy iron is a mass of plastic iron crystals practically gas-free, though the accompanying slag or cinder is wildly gaseous, having received the bulk of the ejected gases.

In the steel-melting furnace the refining or elimination of the metalloids proceeds throughout the operation in a liquid metal mass wherein the imprisoned gases persist and are carried forward and to some considerable extent are entrapped within the frozen ingot.

In the comparatively carbon-free ingot steel of the "Armco" type the presence of imprisoned gases and ferrous oxide at the crystal boundaries differentiate that material from well-worked puddled iron.

In the latter case there can be no remanent entrapped gases to influence and intensify the dilatation incident to cast-iron and steel, thus rendering the working, rolling, drawing or forging at the allotropic change temperatures free from the dangers which accompany the plastic working of "dead-mild" steel at such temperatures. There is little doubt that this property of good wrought-iron accounts for the general reliability of forged and welded articles in iron requiring no after heat-treatment to relieve strains which, in steel, must be set up during mechanical work put on the material during its passage through the recalescence range. Hence the increasing demand and faith in good wrought-iron for smith's work.

It may yet be found that gaseous inclusions in steel influence its welding efficiency, and that the problem of corrosion is similarly related. The need for a *practically conducted* research on the influence of gaseous, oxide, sulphide and slag inclusions as affecting the welding and corrosive properties of iron and steel is urgent.

Yours faithfully,
J. E. FLETCHER, M.I.Mech.E.

Netherton Iron Works, Dudley,
November 27, 1920.

BOOKS RECEIVED.

The "Financial Times" Income Tax Guide. 1920. Revised and enlarged. London: *The Financial Times*, Limited. [Price 1*s.* net.]

The Tenants' Emergency Charter (Houses, Shops, &c.), under the Rent Restriction Act, 1920. Fifth edition. London: Oliver and Boyd. [Price 2*s.* net.]

Fuel Oil in Industry. By STEPHEN O. ANDROS, A.B., E.M. Chicago: Shaw Publishing Company. [Price 3 dols. 75 cents.]

Proceedings of the Staffordshire Iron and Steel Institute, Session 1918–19. Vol. XXXIV. Stourbridge: Mark and Moody, Limited.

United States Bureau of Mines. Bulletins No. 162, *Removal of the Lighter Hydrocarbons from Petroleum by Continuous Distillation, with Special Reference to Plants in California.* By J. M. WADSWORTH. [Price 50 cents.] No. 175. *Experiment Stations of the Bureau of Mines.* By VAN H. MANNING. [Price 25 cents.] Technical Papers No. 230. *Determination of Molybdenum.* By J. P. BOUARDI and EDWARD P. BARRETT. [Price 5 cents.] No. 233. *The Properties of Some Stoneware Clays.* By H. G. SCHURECHT. [Price 10 cents.] No. 238. *Indicators for Carbon Dioxide and Oxygen in Air and Flue Gas.* By L. H. MILLIGAN, D. O. CRITES, and W. S. WILSON. [Price 10 cents.] Washington: Government Printing Office.

Domestic Sanitary Engineering and Plumbing: Dealing with Domestic Water Supplies, Pump and Hydraulic Ram Works, Hydraulics, Sanitary Work, Heating by Low Pressure, Hot Water, and External Plumbing Work. By E. W. RAYNES. Second edition. London: Longmans, Green and Co. [Price 21*s.* net.]

Electric Welding: Its Theory, Practice, Application and Economics. By H. S. MARQUAND. London: Benn Brothers, Limited. [Price 12*s.* 6*d.* net.]

Design of Aeroplane Engines. By JOHN WALLACE. London: Benn Brothers, Limited. [Price 15*s.* net.]

Electric Switch and Controlling Gear. A Handbook on the Design, Manufacture and Use of Switchgear and Switchboards in Central Stations, Factories and Mines. By CHARLES C. GARRARD, Ph.D., M.I.E.E., A.Am.I.E.E. Second edition, revised and enlarged. London: Benn Brothers, Ltd. [Price 25*s.* net.]

The Electrical Handling of Materials. Vol. I. *Electrical Equipment.* By H. H. BROUGHTON, M.I.Mech.E., M.Inst.E.E. London: Benn Brothers, Limited. [Price 25*s.* net.]

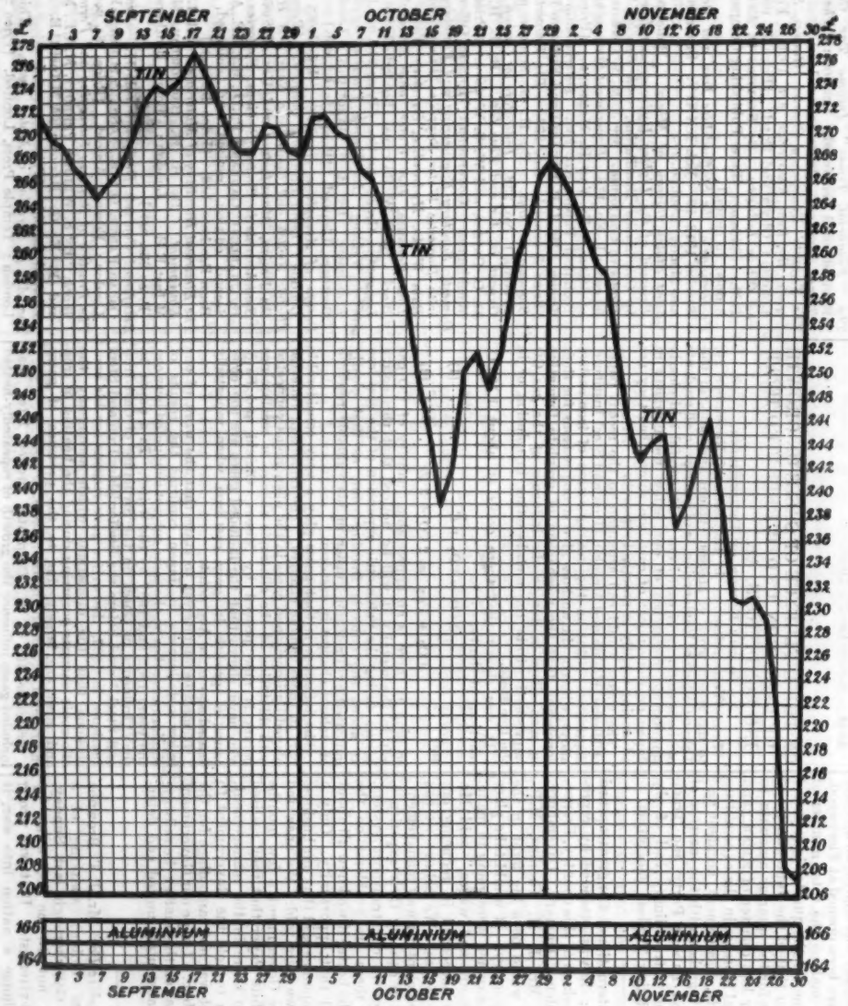
Reinforced Concrete Design. Vol. II. *Practice.* By OSCAR FABER, O.B.E., D.Sc., A.M.Inst.C.E., A.C.G.I. London: Edward Arnold. [Price 18*s.* net.]

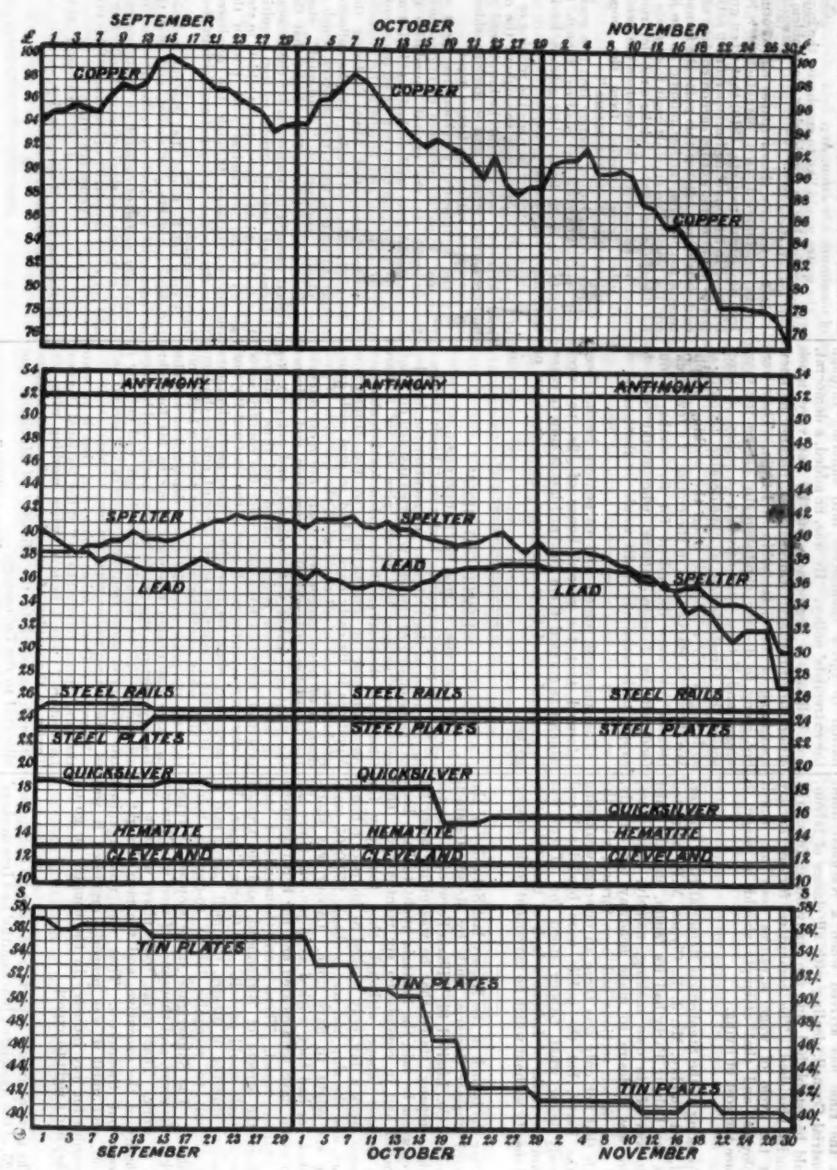
The Practice of Railway Surveying and Permanent Way Work. By S. WRIGHT PERROTT, M.A.I., M.Inst.C.E., and F. E. G. BADGER, A.M.Inst.C.E. London: Edward Arnold. [Price 30*s.* net.]

The Art of Driving a Motor Cycle. Third edition. London: Temple Press, Limited. [Price 2*s.* 6*d.* net.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially compiled from Official Reports of London Metal Markets.)





NOTE.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given, in the case of steel plates, are for ship, bridge, and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for East Coast hematite and Cleveland iron, both of No. 1 quality, and for home consumption. The price of tin plates is per box of I.C. cokes free on board at Welsh ports, but in all other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin plates, where they represent 1*s.* each.

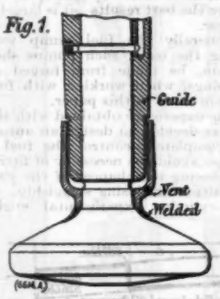
FUEL OIL IN DIESEL ENGINES.

*Some Experiments in Connection with the Injection and Combustion of Fuel Oil in Diesel Engines.**

By Engineer-Commander C. J. HAWKES, R.N.(Ret.), (Member), Professor of Engineering, Armstrong College, Newcastle-upon-Tyne.

THE injection of fuel oil in Diesel engines is of the utmost importance, especially in the case of engines of comparatively high speed, and in dealing with this subject references will be made to experiments which have been carried out at the Admiralty Engineering Laboratory in connection with the development of the high-speed engine for naval purposes. The more general method of injecting fuel oil into a Diesel engine is by the use of compressed air, but considerable advance has been made with the, so-called, solid-injection system. It is now generally known that nearly all British submarine engines are fitted with the solid-injection system

Fig. 1.



—and the credit for this development is due to Messrs. Vickers, Limited. With the air-injection system a definite quantity of fuel oil is pumped into the fuel valve casing, and when the fuel valve is lifted off its seat compressed air, provided by a high-pressure air compressor, blows the fuel oil into the cylinder in a very finely-divided state. In the case of the solid-injection system no air compressor is required. The fuel pump raises the oil in the fuel-valve casing, and in the system generally, to a comparatively high pressure, and when the fuel valve is lifted off its seat the requisite quantity of oil is forced, by its own pressure, through a number of small holes in the sprayer—which causes the oil to be split up into a mist.

It is proposed to refer in the first instance to experiments carried out with the solid-injection system and then to certain experiments with the air-injection system. The single-cylinder four-stroke engine used for the solid-injection tests was the first engine installed in the Admiralty Engineering Laboratory. This engine, which is fitted with a piston of aluminium alloy, has a cylinder diameter of 14½ in., stroke 15 in., and develops 100 brake horse-power (nominal) at 380 r.p.m. The solid-injection fuel valve used during most of the experiments detailed in this paper was of the direct-lift type, *i.e.*, the fuel-valve spindle, which passed through a gland, was operated directly by the fuel-valve lever. The instant of injection of the fuel was adjusted by means of the timing gear which altered the position of the fuel camshaft in relation to the crankshaft. The fuel pump used during the tests was of bronze and the suction and delivery valves were of hardened steel. The fuel-pump glands were packed with Palmetto packing. Owing to the use of very small holes in the sprayer it is imperative that the oil should be thoroughly strained, and strainers are consequently fitted on the suction side and also on the discharge side of the fuel pump between the pressure gauge and the fuel valve. The fuel used during all the solid-injection tests referred to in this paper was shale fuel oil having a specific gravity of about 0·86 at 60 deg. F., flash-point 220 deg. F. (close test) and a viscosity of 43 seconds at 70 deg. F. (Redwood No. 1). The power developed by the engine was absorbed by a Heenan and Froude dynamometer. The counter readings and other records were taken every 15 minutes. In some cases only half-hour tests were made, but, even with such short runs, with the apparatus used and with the engine at working temperatures the records were for all practical purposes accurate. The results given are the means of not less than two tests carried out under the same conditions. In all cases, with the exception of a few runs at low powers, the initial, or maximum, pressure was adjusted by means of the timing gear to about 630 lb. per square inch before commencing a test. The compression pressures used during the tests are shown in the tables of results. Throughout the principal tests the jacket, &c., cooling water was kept at a mean temperature of about 80 deg. F.

On account of the situation of the laboratory it was necessary to fit an exhaust pipe about 180 ft. in length. The engine exhausted into two silencers fitted with water sprays and consequently steam was produced in the exhaust pipe which made it difficult to ascertain the condition of the exhaust with any degree of accuracy. The drainage water from the first silencer was, however, allowed to pass over a glass plate painted white on the under side, and it was found that by this means the condition of the exhaust could be readily ascertained and the presence of even a small quantity of carbon in the exhaust gases was immediately detected. In the results given, therefore, the condition of the silencer drainage water is recorded.

* Abstract of a paper read before the North-East Coast Institution of Engineers and Shipbuilders, November 26, 1920.

The aluminium-alloy piston, which was fitted with six narrow cast-iron rings, was lubricated with the same oil as was used for bearing lubrication. The exhaust valve of the experimental engine was water cooled. During tests which were previously made with this engine it was found that the exhaust valve had a tendency to stick even after a comparatively short period of working. When examined it was found that the clearance between the valve spindle and its guide was always filled with a hard carbon deposit and it was decided to grind the spindle parallel and fit a deflector, as shown in Fig. 1, arranged so that when the exhaust valve opened the spindle was protected from the rush of exhaust gases. This deflector was found to be effective in the experimental engine, and since it has been fitted there has been no sign of sticking of the exhaust valve and the spindle has always been free and clean when removed for examination. The valve spindle is lubricated by means of a mechanical lubricator.

Experiments were carried out at the Admiralty Engineering Laboratory with the object of ascertaining the effect of varying the number and size of the holes in the solid-injection sprayer.

Before commencing these experiments, tests were carried out with the single-cylinder engine at 100 brake horse-power and 380 r.p.m., with a sprayer provided with five holes 0·019 in. in diameter. This sprayer was similar to the sprayers fitted in submarine engines in 1914. It had previously been found that better results could be obtained by increasing the pressure in the system, and Test A, Table I, was therefore carried out with a fuel pressure of 4,000* lb., per square inch (gauge). The fuel consumption was 0·45 lb. per brake horse-power hour, but it must be remembered that the experimental engine has only a single cylinder and it is fitted with a camshaft driving mechanism which was originally made for a multi-cylinder engine of the same design.

It was thought that slightly better results might be obtained if the fuel sprays were passed over a heated surface and a sprayer was therefore made so that each of the five 0·019-in. holes was surrounded by a steel trumpet expanding from $\frac{1}{16}$ in. to $\frac{7}{16}$ in. in $\frac{1}{2}$ in. But a series of tests made with different modification of the trumpets led to no useful result. It was decided, therefore, to proceed no further in this direction.

Several tests were then made with sprayers provided with holes smaller than the standard 0·019 in. As there were, at that time, no suitable drills available the small holes were made by drilling holes about 0·019 in. diameter, caulking them over, and then opening them out again to the size required with a fine tapered reamer. The holes were, therefore, 0·019 in. in diameter with a knife-edged orifice of slightly smaller diameter. Fairly good results were obtained with a sprayer having five 0·015 in. holes, but a sprayer provided with five 0·012-in. holes was not promising. The best all-round results were, however, obtained with a sprayer having five 0·016-in. holes, equally spaced. Tests B and C, Table I, give the results obtained with the 0·016-in. hole sprayer. It will be seen that in each case the fuel consumption is appreciably less than with the 0·019-in. hole sprayer.

TABLE I.—RESULTS OF TESTS WITH VARIOUS SPRAYERS, &c.

Ref. Letter of Tests.	R.P.M.	B.H.P.	Fuel Oil: Opening of Fuel Valve before t.d.c. Deg.	Fuel Oil: Lb. B.H.P. Hour.	Fuel Oil: Pres. Lb. per Sq. In.	Fuel Valve: Sprayer: No. of Holes.	Fuel Valve: Sprayer: Diam. of Holes.	Fuel Valve: Roller Clearance. In.	Compression Pres. Lb. per Sq. In.	Remarks.
A	380·0	100·1	20·0	0·45	4,000	5	0·019	0·030	460	
B	381·5	101·0	10·5	0·42	4,200	5	0·016	0·072	460	
C	377·5	99·4	11·5	0·42	4,500	5	0·016	0·095	460	
D	380·0	100·0	19·0	0·47	4,300	5	0·016	0·003	485	Steel plates used.
E	382·9	101·0	23·0	0·43	3,400	5	0·016	0·003	380	Compression reduced to 380 lb. per square inch.
F	380·3	100·3	12·0	0·42	5,600	5	0·016	0·090	380	
G	380·8	100·4	15·0	0·49	3,700	5	0·016	0·003	490	Piston top covered with plates. Compression increased to 490 lb. due to addition of plates.
H	380·3	100·2	8·0	0·46	5,600	5	0·016	0·100	490	Do. do.
J	378·4	99·8	8·5	0·47	5,700	5	0·016	0·100	490	Steel plates. Fuel oil heated to 400 deg. F. on pressure side.

Fig. 2.

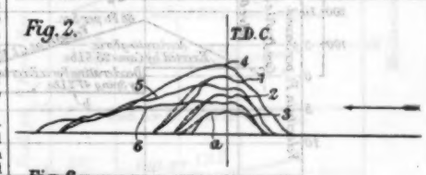


FIG. 2. 5-HOLE SPRAYER. HOLES 0·016, IN. DIAM. REVS. 380. B.H.P. 100.

Curve 1. Barring round Diagram. Notch 4.
Curve 4. Running Diagram, Notch 4. Fuel pressure 3,700 lb.
Curve 2. Barring round Diagram, Notch 3.
Curve 5. Running Diagram, Notch 3. Fuel pressure 5,200 lb.
Curve 3. Barring round Diagram, Notch 2.
Curve 6. Running Diagram, Notch 2. Fuel pressure, 5,600 lb.

Fig. 3.

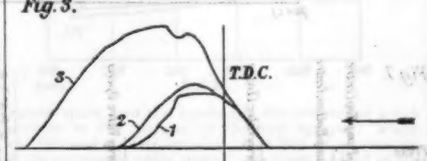


FIG. 3. 4-HOLE SPRAYER. HOLES 0·019 IN. DIAM. 4TH NOTCH OF QUADRANT. FUEL VALVE ROLLER CLEARANCE 0.003. REVS. 380.

Curve 1. Barring round Diagram.
Curve 2. Running Diagram. Fuel pressure, 4,100 lb.
Curve 3. Running Diagram. Fuel pressure, 5,000 lb.

Fig. 4.

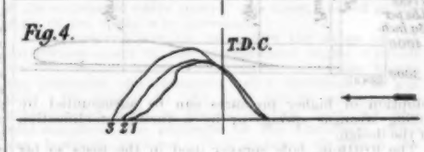


FIG. 4. 5-HOLE SPRAYER. HOLES 0·019 IN. DIAM. 4TH NOTCH OF QUADRANT. FUEL VALVE ROLLER CLEARANCE 0·003. REVS. 380.

Curve 1. Barring round Diagram.
Curve 2. Running Diagram. Fuel pressure, 2,500 lb.
Curve 3. Running Diagram. Fuel pressure, 4,000 lb.

Fig. 5.

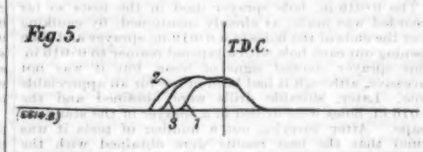


FIG. 5. 5-HOLE SPRAYER. HOLES 0·019 IN. DIAM. 2ND NOTCH. ROLLER CLEARANCE 0·090 IN. R.P.M. 380.

Curve 1. Barring Diagram.
Curve 2. Running Diagram. Spring load of 618 lb.
Curve 3. Running Diagram. Spring load of 750 lb.

* The pressure in the system during all the experiments referred to in this paper was increased as necessary by increasing the clearance between the roller carried by one arm of the fuel valve actuating lever and the fuel cam.

At this stage it was decided to ascertain the effect of fitting steel plates to the top of the aluminium-alloy piston. Five insulated steel places were therefore fitted, each 2½ in. by 2½ in. by ¼ in. thick, in positions such that the fuel sprays would strike them. The fitting of these plates increased the compression pressure by 25 lb. per square inch. The results obtained are shown in Test D, Table I. It will be seen that the effect of the plates was to increase the fuel consumption. Several modifications were tried, with the results recorded in Table I.

When the plates were removed it was found that they had been very hot in places, they were generally free from carbon deposit, and although they were not blistered there were distinct signs of erosion where the fuel jets impinged. The unsatisfactory results were certainly due to delayed combustion—which was clearly shown by the indicator cards and the exhaust temperature.

Up to this time the best consumption figures had been obtained with the sprayer provided with five holes 0·016 in. in diameter, without any special heating devices. Comparing tests E and F, Table I, it will be seen that the fuel consumption was slightly reduced by increasing the fuel-injection pressure. When carrying out tests at higher injection pressures, however, it was noticed that increasing the fuel-valve roller clearance beyond a certain point did not give any better results.

It was also noticed that the fuel-valve roller did not follow the contour of the cam, and it was decided to take valve-lift diagrams from the engine when running. For this purpose an extension was fitted to the fuel-valve spindle, and an ordinary indicator was secured to the fuel-valve body so that the spindle extension pressed against the underside of the indicator piston. The drum cord was then connected to an indicator rig which was approximately 90 deg. out of phase with the piston. By this means the fuel valve lift diagrams were obtained. A 200-lb. indicator spring was used. Copies of actual diagrams, the ordinates of which give the lift of the fuel valve magnified six times, are shown in Figs. 2 to 5. The quadrant of the fuel valve cut-out lever was notched. Notch 4 represents the position in which the fuel valve had its full lift, notch 2 the lowest lift position at which tests were made and notch 3 an intermediate position.

Fig. 2 shows one of the first valve-lift diagrams taken with the sprayer provided with five holes 0·016 in. in diameter.* The effect of "notching out" on the movement of the fuel valve is clearly indicated. Curves 1, 2 and 3 represent the movement of the fuel valve for each position of the cut-out lever when the engine was barred round, *i.e.*, when the fuel-valve roller followed the contour of the cam. The breaks in these curves, *e.g.*, at *a* in curve 3, are due to the backlash of the cam-shaft driving mechanism which is taken up by the load on the fuel-valve spring when the top of the cam passes below the roller. Curves 1, 2 and 3 are, therefore, not correct as drawn, but should be somewhat as shown dotted.

Valve-lift diagrams were also taken with a sprayer provided with four 0·016-in. diameter holes, and these are shown in Fig. 3. With this sprayer the effect of increasing the fuel pressure is most marked—but it must, of course, be regarded as an extreme case. Valve-lift diagrams obtained with a sprayer provided with five 0·019-in. diameter holes are shown in Fig. 4. Curve 1 is the "barring" diagram, and making the necessary correction for the back-lash in the driving mechanism it will be seen from curve 2 that when the engine was running with the normal fuel pressure of 2,500 lb., per square inch the roller practically followed the cam. At a pressure of 4,000 lb. per square inch the roller began to leave the cam (curve 3, Fig. 4). In this instance a valve spring was in use loaded to 618 lb. when the valve was in the closed position. The effect of increasing the spring load was next ascertained. Fig. 5 shows the diagrams obtained with the 0·019-in. hole sprayer. Curve 1 shows the "barring" diagram. Curve 2 is the running diagram with a spring load of 618 lb. and a fuel pressure of 4,500 lb. per square inch, and curve 3 is the running diagram with a spring load of 750 lb. and a fuel pressure of 5,200 lb. per square inch. The quantity of fuel oil passed was the same for curves 2 and 3. The effect of the stronger spring is fairly marked but it is still insufficient to cause the roller to follow the cam. Better results were obtained by increasing the load on the spring to 850 lb., but, with the maximum valve-spindle friction, no appreciable advantage was obtained by increasing the spring load beyond this figure.

It was considered desirable at this stage to investigate the fuel-valve cam, spring, &c., and to ascertain under what conditions "jumping" of the fuel valve was likely to occur. The curves shown in Fig. 6 were therefore prepared. Curve *a* represents the curve of velocity of opening and closing of the fuel valve; curve *b* represents the forces necessary to accelerate and decelerate the valve, &c., curve *c* represents the load due to a 618-lb. spring, and curve *d* the spring load available after deducting the forces necessary to accelerate or decelerate the valve and its operating gear.

TABLE II.—*Variation of Pressure in Injection System.*

Maximum Pressure. Lb. per Sq. In. (a)	Minimum Pressure. Lb. per Sq. In. (b)	Fluctuation of Pressure. Lb. per Sq. In.	Mean of (a) and (b).
4,560	3,440	1,120	4,000
4,320	3,280	1,040	3,800
4,240	3,200	1,040	3,720
4,000	3,040	960	3,520
3,680	2,800	880	3,240
3,480	2,640	840	3,060
3,360	2,560	800	2,960
2,840	2,160	680	2,500
2,360	1,720	640	2,040
2,000	1,400	600	1,700
1,920	1,360	560	1,640

Diagrams had previously been taken from the fuel system with the object of ascertaining the pressure during the cycle. For this purpose an ordinary hydraulic indicator was used, but as whale oil was found to leak past the indicator piston a U-pipe connection was made to the indicator which was filled with a viscous oil—so that the heavy oil was in contact with the piston. This overcame the leakage difficulty, and it is considered that reliable records of the variations of pressure were obtained. Table II shows the maximum and minimum pressures recorded when pumping varying quantities of fuel oil, with the engine running at 420 r.p.m.

A typical diagram taken from the fuel-injection system is shown in Fig. 7. In this instance the indicator drum was running at engine speed and the fuel pump at camshaft speed. The pump dead centres are marked on the diagram.

Referring again to Fig. 6, curve *a* represents the unbalanced oil pressure on the valve on the assumptions that the full pressure is acting during the opening and closing periods of the valve, and that the pressure drops uniformly in the system from 4,500 lb. to 3,500 lb. per square inch. The former is not, of course, correct for all positions of the fuel valve but the latter is approximately correct. Curve *f* shows a similar curve, but it assumes that the pressure in the system drops uniformly from 3,000 lb. to 2,000 lb. per square inch, giving a mean working pressure of about 2,500 lb. per square inch—which was the pressure for which the system was originally designed. The critical period is undoubtedly when the valve begins to close, and if the full pressure acts on the underside of the valve during this period—and it probably does during the early portion of the closing period—it will be seen that the balance of spring load available to overcome gland friction is practically negligible with the higher fuel pressures assumed. Gland friction is acting against the spring during the closing period, whilst the unbalanced pressure on the valve is always acting against the spring. Fuel-valve gland friction is difficult to estimate in an engine running on service. In the case of the experimental engine it was ascertained that with the fuel-valve gland carefully packed (and tight) a force of 8·5 lb. was required to overcome gland friction (diameter of valve spindle $\frac{7}{16}$ in.). This should be regarded as being about the minimum figure. It will be seen that the 618 lb. spring provides only a small margin to overcome an increase in gland friction, or an increased fuel oil pressure beyond that for which the system was originally designed. So far as spindle friction is concerned the use of a "ground" fuel-valve spindle is an advantage—as a gland is then unnecessary. Difficulties following the adoption of higher pressures can be surmounted by fitting stronger springs or by a further modification of the design.

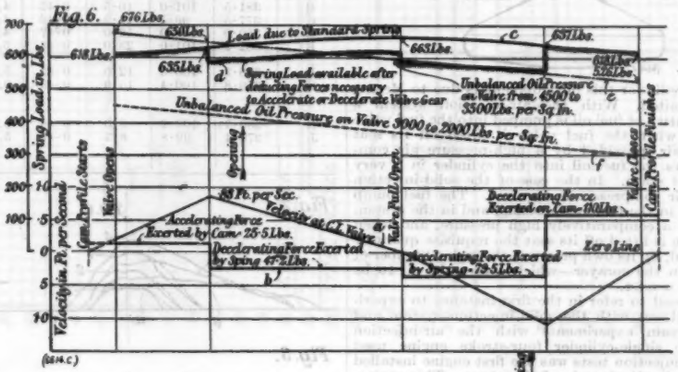


Fig. 6.
676 Lbs.
650 Lbs.
Load due to Standard Springs
c
697 Lbs.
618 Lbs.
663 Lbs.
635 Lbs.
d
Spring Load available after deducting Forces necessary to Accelerate or Decelerate Valve Gear
Unbalanced Oil Pressure on Valve from 4500 to 3500 Lbs. per Sq. In.
Unbalanced Oil Pressure on Valve 3000 to 2000 Lbs. per Sq. In.
Spring Load in Lbs.
Spacing
Valve Opens
Valve Closes
Cam Profile Finishes
88 Ft. per Sec. Velocity at Cut Valve
Accelerating Force Exerted by Cam-25·5 Lbs.
Decelerating Force Exerted by Spring 47·5 Lbs.
Decelerating Force Exerted on Cam-100 Lbs.
Accelerating Force Exerted by Spring-79·5 Lbs.
Zero Line
Velocity in Ft. per Second
Cam Angle
Closing

The success of the solid-injection engine on service, from the point of view of smokeless combustion, depends very largely on the fuel valve and fuel-pump design, correct settings, clean sprayers and tight joints in the system. There should be no difficulty with leakage of connections so long as substantial fittings are provided, but it is advisable to reduce the number of joints to a minimum. It is imperative that every precaution should be taken to ensure the thorough filtration of the fuel oil on its passage to the fuel valve. Although fine filters are fitted occasionally it is found that a choke of one or more holes of a sprayer does occur—especially when the valves and fittings are new. The occasional choking of sprayers on service is probably largely due to pieces of packing working down from the fuel-valve spindle glands, and for this reason, as well as from the point of view of spindle friction, it is advantageous to design the valves so that glands are unnecessary. Pieces of packing from fuel-pump glands also find their way to the sprayers and this points to the desirability of dispensing with packing glands in fuel pumps as well as in the fuel valves.

In the experiments referred to in this paper the best all-round results were obtained with a sprayer provided with five holes 0·016 in. in diameter. Sprayers containing more, and also less, than five holes were tested, but the five-hole sprayer gave the best results within the limits of fuel pressure which the system as designed was capable of withstanding satisfactorily. All the experiments pointed, however, to the desirability, within practical limits, of using smaller holes and higher fuel pressures; and had it been possible to employ higher fuel pressures in the experimental engine there is no doubt that its flexibility would have been increased.

The number and size of the holes in a sprayer depend on the mean pressure in the fuel-injection system; on the viscosity of the fuel oil; on the mean indicated pressure aimed at; on the distance the jets have to penetrate into the combustion chamber and also on the speed of the engine. The angle of the holes, *i.e.*, the angle of the cone on which the holes are drilled, is dependent on the shape of the combustion chamber. So far as the author is aware there are at present no formulæ which can be used to determine the number, size and angle of holes necessary in a sprayer for a given engine to ensure the best results—it is largely a question of trial and error.

Although generally the fuel pump worked satisfactorily during the tests, such pumps should, in the author's opinion, be made from forged steel blocks or steel stampings, when working with fuel pressures of the order mentioned in this paper.

In view of the experience obtained with the direct-lift fuel valve it was decided to design an automatic valve which would completely control the fuel spray, and which would also avoid the necessity of fitting a spindle gland—thus reducing the chances of the valve sticking in the open position or closing sluggishly. In the case of the single-cylinder experimental engine already mentioned it was extremely doubtful whether the existing gears would stand up against its load for any length of time, and with the object of overcoming this difficulty a valve was designed on the lines of that shown in Fig. 8.

With this arrangement the automatic valve is controlled by means of the mechanically-operated spindle or stop A so that the ordinary fuel pump can be used. To operate the valve a lever (not shown in the figure), actuated by the ordinary fuel cam, lifts the spindle A against a spring which corresponds to the spring in the direct-lift type of fuel valve. The fuel pressure in the solid-injection system acting on the piston D then lifts the automatic valve, which is loaded by spring E, and fuel is sprayed into the cylinder. The closing of the automatic valve is brought about either by the fuel pressure falling below that necessary to keep the valve lifted or by the closing movement of the spindle A. It will be seen that the fuel pressure available for spraying is not less than the loading on the valve due to the spring E; and this is a distinct advantage, especially when running at low powers.

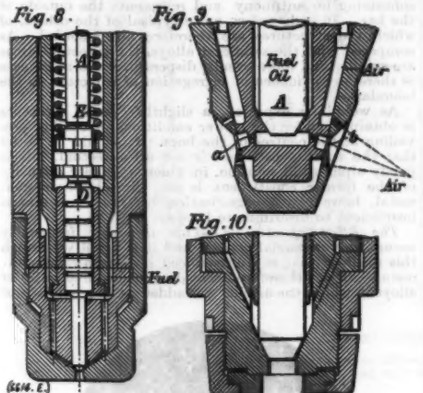
In the direct-lift type of solid-injection fuel valve the spray is obtained by forcing oil at high velocity through small holes in a sprayer; and the pressure available for producing velocity is controlled by the valve. When the valve commences to lift this pressure, due to wire-drawing past the seat, &c., is less than that available in the system, with the result that the spray at the commencement of injection is probably not particularly good. In a similar manner when the valve closes the pressure in the sprayer gradually falls, and it seems reasonable to assume that the last drop of oil goes into the cylinder in the form of a dribble. For this reason it is desirable to close the valve as rapidly as possible. The defects of this type of valve are more marked as the speed of the engine is reduced or the lift of the valve decreased—both of which have an adverse effect on the quality of the spray. This, as already mentioned, is likely to be of greater importance when oils are used which do not come under the heading of "clean" oils.

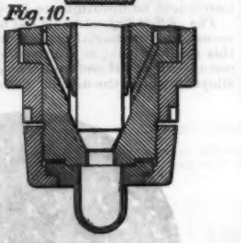
In the case of the automatic valve, shown in Fig. 8, it will be seen that the full fuel pressure is close up to the point of exit of the fuel oil from the sprayer. As soon as the automatic valve lifts the full available pressure causes a fine spray to pass the valve seat. When the valve lifts beyond a certain small amount the spray is formed by the oil being forced through the grooves G at a high velocity and the valve ceases to have any appreciable effect on the quality of the spray. Similarly when the valve closes the control of the spray is taken up by the valve end and a much finer spray is obtained

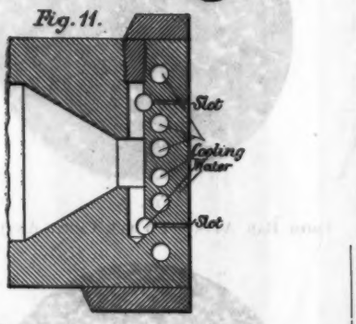
* It was subsequently found that the load on the valve spring in use was slightly less than 618 lb.—which was the load on the standard springs fitted in submarine engines in 1914.

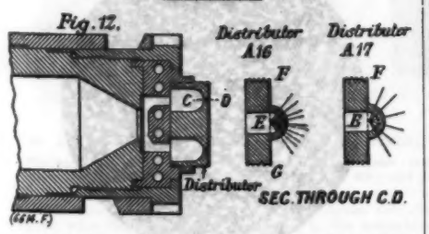
at the instant of closing than is possible with the direct-lift type of fuel valve. The spray past the valve seat, as distinct from the spray resulting from the fuel passing through the grooved plate at high velocity when the valve is clear of its seat, can be made so fine that it has little or no penetrating effect, and therefore such a fine spray is to be avoided, at least in the case of high-speed engines. With the automatic valve, therefore, the closing and opening of the valve should be as rapid as possible.

With the valve shown in Fig. 8 considerable trouble was experienced, as in the case of experimental valves of other designs, due to the inclination of the fuel valve to the axis of the cylinder of the single-cylinder experimental engine. Experiments were made with different types of nozzle plates with the object of turning the spray, and although nearly 100 brake horse-power was developed at 380 r.p.m., the results were unsatisfactory. A very fine spray could be produced with the automatic





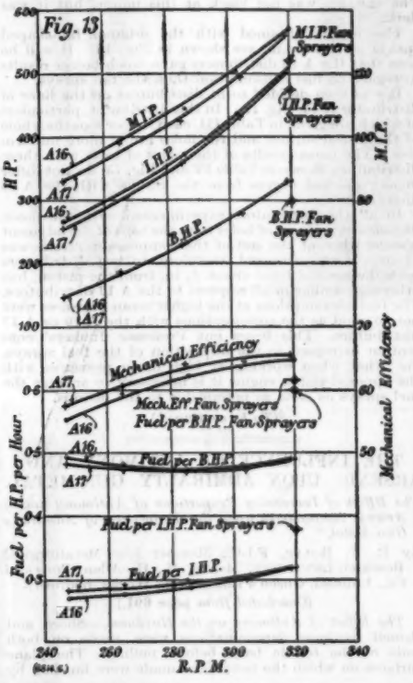




valve, but the moment an attempt was made to deflect the spray the particles of oil coalesced and the energy of the spray was largely lost.

At a later date a new cylinder cover, designed to take a vertical fuel valve, was fitted to the experimental cylinder. When the new automatic valve was made it was tried in an atmospheric testing apparatus, and a very fine spray was produced. The shape of the combustion space of the experimental engine necessitated however, the use of a spray of wide angle, and it was found that considerable energy was lost in producing it. The valve was then tried in the experimental engine, with various numbers and sizes of grooves in the nozzle plate, but only 66 brake horse-power at 380 r.p.m. was reached satisfactorily. Better results would doubtless have been obtained had it been possible to use higher fuel pressures; as the energy of the fine sprays produced would thereby have been increased, resulting in an improvement in the penetration, and consequently in the distribution, of fuel oil in the combustion space. At low speeds the automatic valve was very satisfactory, and it was found that the engine could be run for long periods at 6 brake horse-power and 116 r.p.m., whereas with the direct-lift type of injection valve it was difficult to run the engine below 25 brake horse-power at 140 r.p.m. without misfiring. When the automatic valve was in use at the lowest power an indicator diagram was taken with the pencil held on the paper during six successive injections of fuel and only a single line diagram was recorded, indicating that the firing was certain and regular, and that the automatic valve was superior to the direct-lift injection valve for low-speed running.

From the experience gained it was evident that with an automatic valve on the lines of Fig. 8 satisfactory results could be obtained with the fuel pressure used owing to the shape of the combustion chamber of the experimental cylinder. To use solid-injection satisfactorily it is necessary to pulverise the fuel oil as finely as possible, and at the same time to produce a spray with sufficient penetration to ensure that the fuel is brought in contact with the air required for its combustion. Unfortunately these two requirements are incompatible, and it is necessary therefore to effect a compromise—and this compromise can only be reached largely by trial and error. In the case of the automatic valve shown in Fig. 8 the pulverisation was excellent but the penetration was poor, *i.e.*, the energy of the sprays, owing to their finely-divided state, was rapidly lost when they entered the compressed air in the combustion space, and this resulted in the presence of a rich mixture in the vicinity of the fuel sprayer; which was followed by late burning. The lack of penetration of the automatic valve sprayer was more marked as the angle of the spray was increased.



As it was not possible to modify the shape of the combustion space of the experimental engine without considerable structural alterations, or to employ higher fuel pressures, the automatic valve described was put aside. In nearly all the fuel valves subsequently experimented with at the laboratory, both air and solid-injection, the principle of the automatic valve was, however, retained; but in order to obtain the necessary penetration of the sprays multi-hole sprayers were employed on the lines of the direct-lift fuel valve previously referred to.

Good results have been obtained at the Admiralty Engineering Laboratory with solid-fuel injection, but in nearly all cases shale fuel oil has been used in the tests. A few tests were carried out with Texas and American distillate oils and satisfactory results obtained, but no other fuel oils have so far been tested. It would be interesting to hear whether smokeless combustion has been obtained with fuel oils other than those referred to above, in an engine running at 380 r.p.m. and at not less than 100 lb. mean indicated pressure. The problem is perhaps less difficult in the case of engines of slower speed working at comparatively low mean pressures.

Experiments were carried out with the object of ascertaining whether improved results would be obtained with the solid-injection system by increased turbulence, due to increasing the velocity of the air through the induction valve. These experiments indicated that there was no improvement due to increased turbulence; in fact, the fuel consumption was slightly increased and the exhaust was slightly shaded. On the face of it, it would appear that turbulence would assist combustion in the case of the Diesel engine—but it will be seen that a high degree of turbulence might have a harmful effect by distorting the spray and causing a portion of it to be brought in contact with the comparatively cool walls or cover of the engine before the oil globules had completely vaporised. This action would produce a smoky exhaust. It is very essential that a fuel spray should not strike a cool surface, and as a high degree of turbulence would have a tendency to bring this about it is considered that turbulence is not so desirable in the Diesel engine as it undoubtedly is in the explosion engine. The turbulence referred to is, of course, that due to high air speeds through the induction valve and not to the use of blast air in air-injection engines. Blast air splits up and distributes the fuel oil in the combustion space, but it acts symmetrically about the centre line of the sprays and its direction of action is under control (depending on the position, size and shape of the holes in the distributor or flame plate); consequently it is much less likely to drive a portion of the fuel on to the cool walls of the liner and cover.

There is no doubt that solid injection has much to recommend it, so long as it is in every way satisfactory on service. By its adoption it is not necessary to make provision for an air compressor for supplying blast air—and the high-pressure compressor, as is well-known, has in some instances been a continued source of trouble. Air injection is, however, principally used to-day, and it seems fair to presume, therefore, that many manufacturers have largely, if not entirely, overcome their compressor troubles. So far as present experience is concerned it is considered that a greater variety of fuel oils can be used satisfactorily with air injection than with solid injection. With the fuel oils experimented with at the laboratory it has been found that up to about 100 lb. mean indicated pressure the fuel consumption with solid injection is approximately the same as the fuel consumption with air injection, at the same power and speed, after taking into account the power required to drive the injection compressor. This means that whilst the consumption per brake horse-power is the same with both systems the consumption per indicated horse-power is less with the air-injection engine than with the solid-injection engine—*i.e.*, the combustion of the fuel oil in the air-injection engine is slightly better than in the solid-injection engine. This difference is no doubt largely due to the better and more rapid distribution of the fuel oil mist in the compression space, which naturally follows the use of air for injection purposes, as the sprays have more energy, and the air when it expands in the combustion space carries the fuel-oil mist with it. Owing to the cooling effect of the injection air, however, a higher compression is necessary in the air injection engine than in the solid-injection engine, for the same fuel oil. It is also found that the solid injection engine starts more readily from the cold condition than the air-injection engine, although in this connection much depends on the compression ratio and on the type of sprayer employed.

At mean indicated pressures at and above 110 lb. per square inch, the experimental engine running at 380 r.p.m., smokeless combustion could not be satisfactorily obtained with the solid-injection system, and as it was desirable that higher mean indicated pressures should be developed, it was decided to experiment with the air-injection system. The ordinary air-injection valve will be referred to later, but it is proposed briefly to refer, at this stage, to a valve which may be regarded as a combination of the air and solid-injection systems.

In the ordinary air-injection valve the fuel is forced into the fuel-valve casing against the pressure of the injection air, but no advantage is derived from the pressure to which the fuel oil is subjected. In the modified valve the oil is sprayed in the manner common to solid-injection systems, but inside the cylinder it meets a jet or jets of air so that the distribution is thereby improved. It was hoped that by the use of such a valve a smaller quantity of blast air would be required than is necessary with the ordinary air-injection valve. Further, in the event of the air compressor failing the engine would be able to run at a slightly lower power satisfactorily on solid injection alone. Various valves were tried based on this principle, both with the air jets surrounding the fuel jets, and also with the fuel jets surrounding the air jets, but it is not possible within the limits of this paper to refer to more than one valve which has given promising results when using shale fuel oil.

Fig. 9 shows diagrammatically a section of the sprayer end of the valve. A is lower end of the automatic valve and the fuel oil passes into the combustion space through the small holes *a*, *b*, &c., when the valve is lifted. Four air holes surround each fuel exit, so that four small air jets meet the fuel spray in the combustion space at a small angle. In the experimental engine an air valve operated by a separate cam controls the supply of high-pressure air to the air channels shown. This arrangement was made to facilitate experiment, but it is probable that in a valve of this type for service use one cam would be used for controlling the admission of both air and fuel. The engine can be started on the solid-injection system alone, and therefore it is possible to employ a lower compression ratio than would suffice to ensure an easy start from the cold condition with the ordinary air-injection system in use.

It has so far been found that with this valve smokeless combustion can be obtained with a mean indicated pressure of just over 130 lb. per square inch—the experimental engine running at 380 r.p.m. The consumption of blast air is slightly less than with the ordinary air-injection valve. The fuel consumption at about 130 lb. mean indicated pressure, using shale fuel oil, is just under 0·41 lb. per brake horse-power, but as the air compressor is driven by an electric motor this does not take into account the power required to supply the blast air. The valve combining the solid and air-injection systems has some advantages over the ordinary air-injection valve, but it undoubtedly involves greater complication. Experiments are being continued, and the question of its adoption will, of course, depend upon the results obtained after prolonged trials.

When using the ordinary air-injection system for developing comparatively high mean pressures in high-speed engines it is necessary to use a distributor provided with holes so that a number of small jets are produced. Fig. 10 shows the lower end of a fuel valve

designed for a 20-in. by 20-in. experimental four-stroke cycle engine. The number and size of the holes in the distributor to give the best all-round results is a question of trial. The angle of the holes, as in the case of the solid-injection sprayer, is largely dependent on the shape of the compression space.

A few details of tests carried out with various fuel-valve distributors in a single-cylinder opposed-piston two-stroke engine may be of interest. This engine was designed and constructed by Messrs. William Doxford and Sons, Sunderland, originally for their own use, but before the engine had been run it was transferred to the Admiralty Engineering Laboratory. The engine follows the firm's usual design and has a cylinder diameter of 14·55 in. and a combined stroke of 28·3 in. It is fitted with two water-cooled fuel valves. The double-acting scavenge pump and four-stage air compressor are driven from two cranks on an extension of the engine shaft. The scavenge pump and compressor were made larger than necessary for ordinary running, for the purpose of supercharging experiments at a later date, and consequently this reduced slightly the mechanical efficiency of the engine. During the tests referred to in this paper the engine, owing to the lay-out of the laboratory, exhausted into a pipe 180 ft. in length.

Table III.

Distributor A 16.

Diameter of hole, in. . .	0·031	0·047	0·055	0·058	0·062	0·063	
Angle of top jets, deg.	37·0	51·5	63·5	74·0	85·0	92·5	Angles measured from EF.
Angle of bottom jets, deg.	21·0	34·0	46·5	57·5	66·5	76·0	Angles measured from EG.

Distributor A 17.

Diameter of hole, in.	0·047	0·05	0·047	0·05	0·058	0·047	
Angle of jets, deg.	40·0	60·0	88·0	115·0	138·0	158·5	Angles measured from EF.

Table IV.—*Mean Results of Two Tests at Each Power with each Type of Distributor.*

Distributor.	R.P.M.	M.I.P.	I.H.P.	B.H.P.	Mech. efficiency. Per cent.	Fuel Oil, Lb. per H.P.-Hr.		Blast pressure. Lbs. per sq. in.	Temp. of exhaust gases. Deg. F.
						Per I.H.P.	Per B.H.P.		
A16	320	134	511	331	64·7	0·32	0·49	1,325	760
A17	319	132	504	330	65·6	0·32	0·49	1,325	—
A16	303	121	437	277	63·4	0·3	0·48	1,225	668
A17	304	119	432	278	64·3	0·3	0·47	1,225	—
A16	286	109	370	230	62·2	0·29	0·47	1,100	606
A17	285	105	359	230	64·0	0·3	0·47	1,100	—
A16	265	99	312	185	59·3	0·28	0·48	1,000	540
A17	265	98	305	185	60·6	0·29	0·47	1,000	—
A16	247	89	263	145	55·2	0·27	0·49	900	525
A17	247	86	253	145	57·3	0·28	0·48	900	—

Texas fuel oil used, specific gravity 0·91 at 60 deg. F. Exhaust clear throughout. Temperature of exhaust taken by thermo-couple. Cams in use: Front cam opened 19 deg. before T.D.C., closed 41 deg. after T.D.C.; back cam opened 6 deg. before T.D.C. and closed 32·5 deg. after T.D.C.

The sprayer or distributor, of each fuel valve as originally designed was provided with two narrow slits intended to give horizontal fan-shaped sprays. The centre line of each spray was about $\frac{1}{2}$ in. from the top of the adjacent piston—the distance between the pistons at the end of the compression being about 1·75 in. A number of tests at various powers were carried out with the original distributors shown in Fig. 1 with various shapes of cams, &c., and it was found that the fuel consumption at the higher powers and speeds increased rapidly with an increase in mean pressure. From the experience gained with the experimental 14½ in. by 15 in. four-stroke engine it was clear that fuel sprays having a comparatively large surface were not satisfactory, as when working at high speeds and high mean indicated pressures late burning resulted. It was decided, therefore, that further improvements in the fuel consumption of the opposed-piston engine could only be obtained by replacing the original distributors by distributors provided with a number of holes. The design of the original valves was such that it was necessary to cut off the ends of the valve bodies and replace them by ends which could be adapted to take experimental distributors provided with circular holes. Fig. 12 shows the experimental distributors as fitted.

Each distributor was provided with two rows of holes. The centre lines of the holes were made parallel to the flat tops of the pistons, and the angles of the holes in the horizontal plane were arranged to give the best distribution. The diameter of each hole depended on its distance from the cylinder liner in the direction of the spray and on the volume of that portion of the combustion space which it had to feed, and it was arranged that each row of holes should sweep over approximately half the surface of the adjacent piston. (The centre lines of the two fuel valves in the horizontal plane are parallel but slightly off-set.) A number of distributors of this type were tested, and it was found that the best all-round results were obtained with the distributor A 16, of which a horizontal section is shown in Fig. 12. The upper row of holes in each distributor is indicated in the figure by the full lines and the lower row of holes by the dotted lines. Table III gives the sizes and angles of the holes. The mean results of a series of tests carried out with the A 16 distributors are shown in Table IV and Fig. 13. The fuel used was Texas fuel oil having a specific gravity of 0·91 at 60 deg. F., flash-point 195 deg. F. (close test), viscosity 318 seconds at 70 deg. F. (Redwood No. 1), and a calorific value of 18,400 British thermal units (lower heating value). The exhaust was clear throughout the tests.

The maximum power developed by the A 16 distributors was 406 brake horse-power at 364 r.p.m., the mean indicated pressure being 150 lb. per square inch. The exhaust was not black at this power, but it was dark.

The results obtained with the original fan-shaped sprays at 320 r.p.m. are shown in Fig. 13. It will be seen that the A 16 distributors gave much better results in regard to fuel consumption than the fan sprays.

It was then decided to fit distributors on the lines of distributor A 17, Fig. 12. In this distributor, particulars of which are given in Table III, each row sweeps the whole of the piston surface and the holes are of more uniform size. The mean results of the series of tests with these distributors, shown in Table IV and Fig. 13, do not differ in any marked degree from the results with the A 16 distributor.

In all the distributors experimented with the mean distance of the rows of holes from the tops of the adjacent pistons when at the end of the compression stroke was $\frac{3}{32}$ in. It was arranged, therefore, to test distributors with the rows of holes about $\frac{2}{32}$ in. from the piston, but otherwise similar in all respects to the A 17 distributors. The fuel consumptions at the higher mean pressures were not so good as the consumptions with the A 16 or A 17 distributors. This bears out Professor Junkers' contention in regard to the disposition of the fuel sprays, viz., that when working at high mean pressures with the opposed-piston engine it is necessary to arrange the fuel sprays as close as practicable to the pistons.

(To be continued.)

THE INFLUENCE OF ANTIMONY AND ARSENIC UPON ADMIRALTY GUN-METAL.

*The Effect of Increasing Proportions of Antimony and of Arsenic Respectively upon the Properties of Admiralty Gun-Metal.**

By R. T. Rolfe, F.I.C., Member (the Metallurgical Research Laboratory, Messrs. W. H. Allen, Sons and Co., Limited, Queen's Engineering Works, Bedford).

(*Concluded from page* 691.)

The Effect of Antimony on the Hardness.—Shore and Brinell hardness determinations were made on both ends of the tensile bars, before pulling. The plane surfaces on which the tests were made were finished by Hubert's No. 1 emery paper, it having been found that no differences were obtained in the average Shore figure by finishing with either No. 0 or No. 00 paper. All Shore figures the author quoted are a mean of seven determinations, and all Brineli figures a mean of three, with a pressure of 500 kg. The efficacy of the Brinell test on gun-metal is, however, rather invalidated by the fact that the impressions are not truly circular, and it is therefore necessary to measure the diameter of a particular indentation in several different directions before being certain of even an approximate result. (The results obtained were tabulated in the paper.) They are rather irregular, and have therefore not been plotted as curves. They show, however, that antimony is a hardener of gun-metal, and this tendency is fairly well shown in both sand- and chill-cast alloys.

The Effect of Antimony upon the Microstructures.—The sand-cast bars of the melt, $A1S_1$, $A2S_1$, $A3S_1$ and $A4S_1$, were examined and were photographed, at the centres of the bars, and in the same relative position in each bar. There are no very marked differences between the structures of the four. Fig. 7 shows the microstructure of the alloy containing no antimony, and this structure may be regarded as quite sufficiently representative of the alloys containing, respectively, 0·5 per cent. antimony and 1 per cent. antimony, the photographs of which are therefore not put on record. It is only in the case of the 1·5 per cent. alloy, shown at Fig. 8, that there appears to be any special tendency towards the segregation of a greater amount of eutectoid at the crystal boundaries. In this alloy, too, the quantity of eutectoid appears somewhat greater.

The chill-cast bars $A1C_1$, $A2C_1$, $A3C_1$ and $A4C_1$, were examined and were also photographed, at both the centres and the outsides of the bars. No appreciable differences in structure can be noted as the proportion of antimony increases. Fig. 9 is from $A1C_1$, the alloy containing no antimony and represents the outside of the bar. It is, however quite typical of the others, of which the structures are therefore not recorded. As compared with the sand-cast alloys, the eutectoid areas are smaller and more evenly dispersed, while in no case is there any evidence of segregation of eutectoid to the boundaries.

As would be expected, a slightly coarser structure is obtained under the slower conditions of cooling prevailing at the centres of the bars. It should be noted that the white constituent is not all eutectoid, but is partly alpha solid solution, in which a smaller quantity of the former constituent is set. In chill-cast gun-metal, however, a magnification of 150 diameters is insufficient to discriminate between the two.

The Effect of Arsenic.—This impurity frequently occurs in commercial copper, and it is usually through this medium that it is introduced into Admiralty gun-metal. It was therefore decided to make three series of alloys in which the arsenic was added at the expense of the copper. In these experiments a change was made in the copper, Rio Tinto B.S. being used instead of Bibby's. For the purpose of adding the necessary proportion of arsenic to the respective melts of gun-metal, a cupro-arsenic alloy was first prepared by melting 20 lb. of copper and adding to it ¼ lb. of arsenic metal lump, supplied by the British Drug Houses, Limited, by which means an alloy was obtained containing on analysis 3·42 per cent. of arsenic.

A complete analysis of the copper used for the manufacture of the cupro-arsenic and later for the preparation of all three alloys is given in the next column.

Three different compositions were then made, a melt and a re-melt being obtained from each. Each melt was of 50 lb. (The quantities of the different constituents taken were stated in a table.) The residue from each melt, after casting the sand and chill bars (two of each) was run into ingots, which were run down as a separate lot without any further addition, and described as re-melt. The micro-pieces were cut off the top ends of the arsenical test bars, both sand and

Fig. 8.

From Bar $A4S_1$. 1·5 per Cent. Antimony.

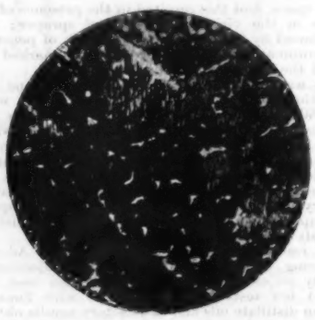


Fig. 7.

From Bar $A1S_1$. No Antimony.

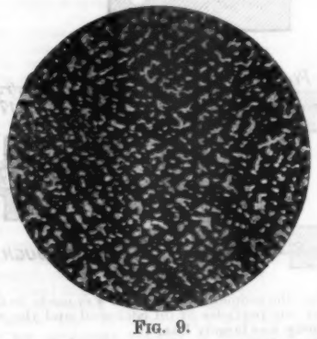


Fig. 9.

From Bar $A1C_1$ (outside). No Antimony.

Magnification in all cases 150 Diameters. Etched with Acid Ferric Chloride.

(Reduced by One-Third.)

* Abstract of a paper read before the Institute of Metals, at Barrow-in-Furness, on September 6.

chill, instead of the bottom ends, as was done for the antimonial bars. (Fig. 1, page 690 *ante*.) The compositions aimed at and the complete analysis of all the six alloys, three from melts and three from re-melts, actually obtained, were detailed, the author adding that an interesting point about this series of alloys was the cast arsenic series, re-melt, $B1S_1$ and $_2$ to $B3S_1$ and $_2$, after pulling; Fig. 12, chill-cast arsenic series, re-melt $B1C_1$ and $_2$ to $B3C_1$ and $_2$, before machining.

The results are plotted in Figs. 13 and 14, and present some peculiarities. Thus the results from the melts of the sand-cast bars are very different from those of dogmatic as to the maximum quantity of this impurity permissible. Here the author feels that it is safer to rely upon the results of a large number of foundry tests, especially when considerable support as to the correctness of the deductions from these is to be obtained from the results of the present research. He

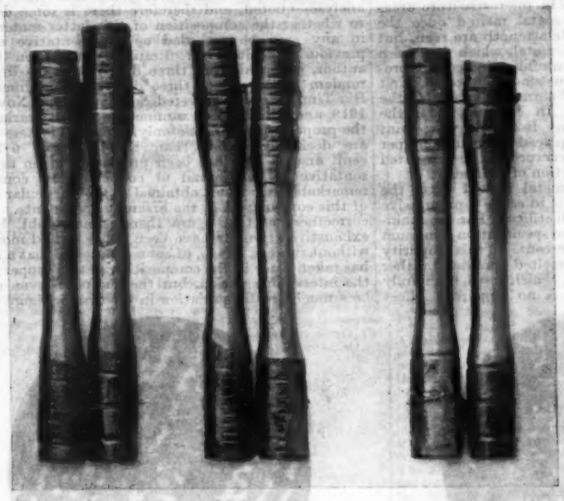


FIG. 10. SAND-CAST ARSENIC SERIES (MELT), AFTER PULLING.

The test-bars are, from left to right in pairs, as follows: $A1S_1$ and $_2$ (0·04 per cent. arsenic), $A2S_1$ and $_2$ (0·42 per cent. arsenic), and $A3S_1$ and $_2$ (1·01 per cent. arsenic).

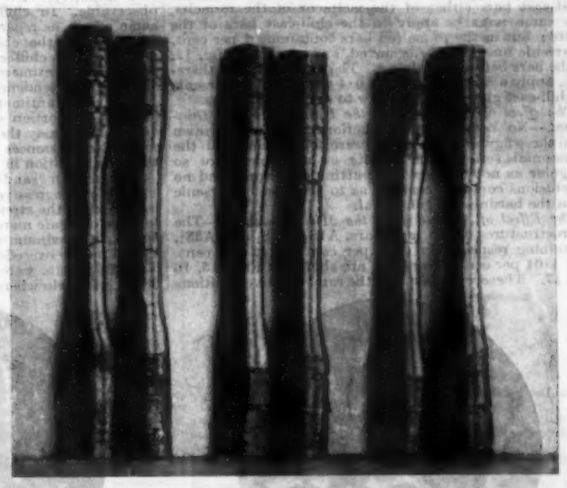


FIG. 11. SAND-CAST ARSENIC SERIES (RE-MELT), AFTER PULLING.

The test-bars are, from left to right in pairs, as follows; $B1S_1$ and $_2$ (0·04 per cent. arsenic), $B2S_1$ and $_2$ (0·42 per cent. arsenic), and $B3S_1$ and $_2$ (1·01 per cent. arsenic).

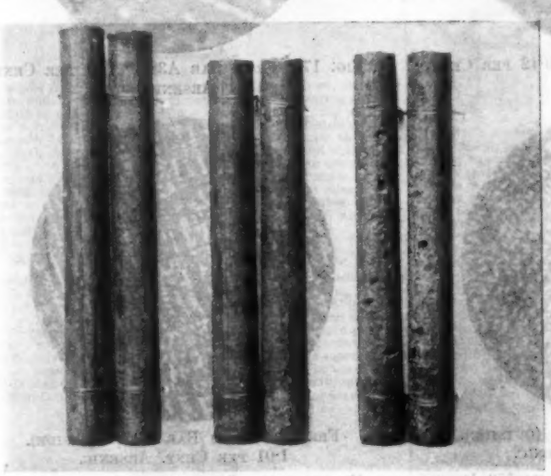


FIG. 12. CHILL-CAST ARSENIC SERIES (RE-MELT), BEFORE MACHINING.

The test-bars are, in pairs from left to right, as follows: $B1C_1$ and $_2$ (0·04 per cent. arsenic), $B2C_1$ and $_2$ (0·42 per cent. arsenic), and $B3C_1$ and $_2$ (1·01 per cent. arsenic).

almost exact coincidence of the arsenic figure actually found with that theoretically existing in the respective alloys, as determined by calculation from the proportions of this impurity in the component metals.

	Rio Tinto B.S. Copper. Per Cent.
Arsenic	0·056
Antimony and tin	nil
Lead	trace
Iron	0·014
Bismuth	nil
Sulphur, nickel and zinc	traces
Oxygen, &c.	0·030
Copper	99·900
	100·000
Copper results (vol.)	99·87
Copper results (vol.)	99·93

This demonstrates that, contrary to a quite commonly held belief, there is no loss of arsenic in melting or in re-melting gun-metal. The same variation as in the first series of tests is shown in the zinc figure, in one alloy a very low result being obtained in both melt and re-melt. Only traces of antimony occur in any of the alloys, while the other impurities are fairly constant and are about as in the case of the other series.

The effect of Arsenic upon the Mechanical Test Results.—Some of these sets of bars are shown in Figs. 10 to 12, as follows: Fig. 10, sand-cast arsenic series, melt, $A1S_1$ and $_2$ to $A3S_1$ and $_2$, after pulling; Fig. 11, sand-the re-melts. In the melts, the increase of arsenic appears to lead to a falling-away both in the ultimate stress and elongation figures, while in the re-melts the results for all three alloys do not show this tendency, and the results are all very much the same as each other. This may be regarded as an argument for melting gun-metal twice, the first time as ingots and the second time for the castings, and this practice is sometimes actually employed. It is, however, an expensive and quite unnecessary process, if materials of reasonable purity are used.

Disregarding, therefore, the question of melting twice, except in so far as it arises in the use of a certain amount for returned scrap, it appears that in sand-cast gun-metal arsenic is a prejudicial impurity.

It is a little unfortunate that the arsenic results are much more irregular than those of the antimony, and for this reason one would have preferred to have the results of a greater number of bars before being too would therefore limit the proportion of arsenic to 0·3 per cent.

In the chill-cast bars, no very pronounced correlation occurs between the mechanical test figures and the proportion of arsenic (see Fig. 14).

(The results from the 1 per cent. arsenic alloy were compared with Johnson's figures* from his alloy of approximately the same composition.) As to the dis-

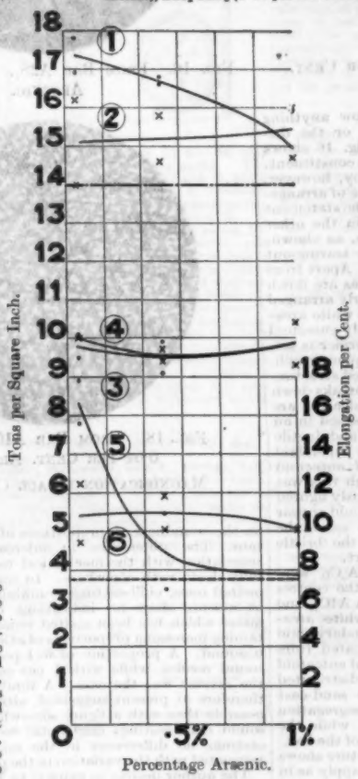


FIG. 13. SAND CAST.

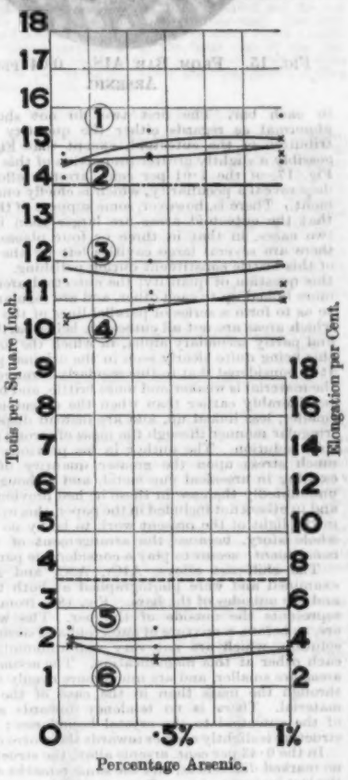


FIG. 14. CHILL CAST.

Curve (1), representing ultimate stress (melt); curve (2), representing ultimate stress (re-melt); curve (3), representing yield point (melt); (curve (4), representing yield point (re-melt); curve (5) representing elongation (melt); curve (6) representing elongation (re-melt); ——·——·—, Admiralty minimum figure for ultimate stress; – – – –, representing Admiralty minimum figure for elongation per cent.

* Journal of the Institute of Metals, No. 2, 1918, vol. xx, pages 176 and 177.

crepancies between these results, the same remarks apply as in the case of antimony. The author does not regard a figure of 23 or even 19 tons as fairly representative of the strength of chill-cast gun-metal containing 1 per cent. of arsenic, nor 15·5 per cent. as typical of its ductility.

The effect of Arsenic upon the Soundness of the Castings.—No difference in this respect was observed in the sand-cast bars either of the melts or of the re-melts. The same remarks apply to the chill-cast bars of the melts; but in the re-melted bars containing 1 per cent. of arsenic unsoundness occurred, as is shown in Fig. 12, of the bars before machining. The author would, therefore, apply a limiting figure of 0·4 per cent. for arsenic in chill-cast gun-metal, in order to ensure soundness.

The effect of Arsenic upon the Hardness of the Gun-Metal.—No satisfactory deductions could be drawn from these figures, although all were determined, as in the antimonial series. The results as a whole were so irregular as not to be worth putting on record, and no conclusions could be come to as to the effect of arsenic upon the hardness of gun-metal.

The Effect of Arsenic upon the Microstructures.—The microstructures of the sand bars, $A1S_1$, $A2S_1$ and $A3S_1$, containing respectively 0·04 per cent., 0·42 per cent. and 1·01 per cent. of arsenic, are shown in Figs. 15, 16 and 17. These were taken at the same relative positions

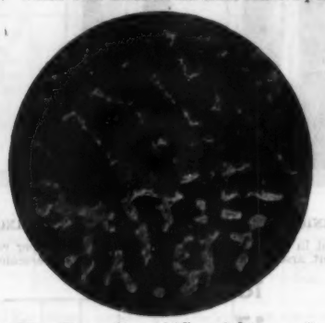


FIG. 15. FROM BAR $A1S_1$. 0·04 PER CENT. ARSENIC.

FIG. 16. FROM BAR $A2S_1$. 0·42 PER CENT. ARSENIC.

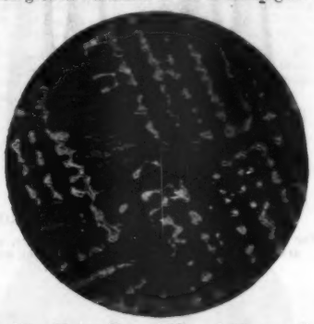


FIG. 17. FROM BAR $A3S_1$. 1·01 PER CENT. ARSENIC.

in each bar. The first two do not show anything abnormal as regards either the quantity or the distribution of the eutectoid, except that Fig. 16 shows possibly a slightly greater proportion of this constituent. Fig. 17, of the 1·01 per cent. arsenic alloy, however, does reveal a peculiarity, which is chiefly one of arrangement. There is, however, some support of the statement that the eutectoid areas are larger than in the other two cases, in that in three or four places, as shown, there are several large cavities left by the tearing-out of this brittle constituent during polishing. Apart from this question of quantity, the eutectoid areas are much more linked up to each other, and are regularly arranged so as to form a series of parallel lines of the white areas which areas are not all eutectoid, being partly eutectoid and partly secondary alpha, in which the former is set, this being quite clearly seen in the original photograph. It is considered that in this regularly-arranged structure the material is weaker and more brittle, and breaks down considerably earlier than when the eutectoid areas are smaller, less linked up, and are instead dispersed in an irregular manner through the mass of strong and ductile solid solution. The author in his previous paper laid much stress upon the greater quantity of eutectoid existing in arsenical gun-metal, and although this was undoubtedly the case in those he had previously figured and in others not included in the paper, this would appear in the light of the present work to be by no means the whole story, because the arrangement of the brittle constituent seems to play a considerable part.

The chill-cast alloys, $A1C_1$, $A2C_1$ and A_3C_1, were examined and were photographed at both the centres and the outsides of the bars. Fig. 18 is from $A1C_1$, and represents the outside of the bar. The white areas are, as before, a mixture of eutectoid and secondary solid solution, which are not very well differentiated from each other at this magnification. The actual eutectoid areas are smaller, and are much more evenly distributed through the mass than in the case of the sand-cast material. There is no tendency towards segregation of the eutectoid to the crystal boundaries; while the structure is slightly coarser towards the centre of the bar.

In the 0·42 per cent. arsenic alloy, the structure shows no marked differences, and the same remarks apply as in the last instance.

Fig. 19, from the 1 per cent. arsenic alloy (outside of bar), should be compared with Johnson's Fig. 4* of his corresponding alloy, which it closely resembles; although, as before shown, a similarly close agreement in the mechanical test results was not obtained. It should be noted that in this alloy, in the case both of Johnson's and the author's figures, the same regular arrangement of the eutectoid areas is seen, as has already been referred to with the 1 per cent. alloy in the sand-cast condition.

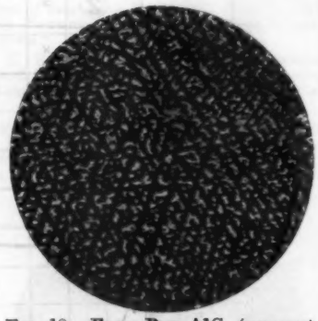


FIG. 18. FROM BAR $A1C_1$ (OUTSIDE). 0·04 PER CENT. ARSENIC.

FIG. 19. FROM BAR $A3C_1$ (OUTSIDE). 1·01 PER CENT. ARSENIC.

MAGNIFICATION IN ALL CASES 150 DIAMETERS. ETCHED WITH ACID FERRIC CHLORIDE. (REDUCED BY ONE-THIRD.)

CONCLUSIONS.

Antimony.—In sand-cast gun-metal, the effect of a progressive increase in the proportion of antimony is in the direction of hardening and embrittling it, also a progressive falling-away in the strength and ductility. With 1 per cent. antimony the ultimate stress figure approximates to, while the elongation figure falls just below, the minimum laid down by the Admiralty specification. Therefore, the maximum permissible amount of this impurity appears to be in the region of 0·75 per cent. There is no apparent effect on the soundness of sand-cast gun-metal containing up to 1·5 per cent. of this impurity. No difference in microstructure areas observable. In chill-cast gun-metal melted once the same effects as regards ultimate strength are seen, but modified by the chilling. In metal which has been melted, twice, chill castings containing increasing proportions of antimony are increasingly unsound, first showing this tendency to an abnormal degree with the 1 per cent. antimony alloy. In chill castings, the limiting proportion of antimony from the view-point of soundness may therefore be placed at about 0·75 per cent. No differences in microstructure can be correlated with the variation in the proportion of antimony.

Arsenic.—In sand-cast gun-metal melted once, the effect of a progressive increase is to cause a progressive falling-off in the strength and ductility. For the maintenance of a safe margin over the specification minimum figures, a maximum of 0·3 per cent. of this impurity should not be exceeded. In re-melted gun-metal rather different results were obtained, which have been fully dealt with elsewhere. There is no apparent effect on the soundness of proportions of arsenic up to 1 per cent. The differences in microstructure and their correlation with the mechanical test results have been fully dealt with elsewhere. In metal which has been melted once, chill-castings containing up to 1 per cent. of arsenic show no indications of unsoundness. In metal which has been melted twice, chill-castings containing increasing proportions of arsenic are progressively unsound. A proportion of 0·4 per cent. arsenic gives sound results, while with 1 per cent. of the impurity the reverse was the case. A limit of 0·4 per cent. is therefore at present suggested, although it is naturally possible that with a figure somewhat higher than this, sound chill castings might still be obtained. In chill castings no differences in the microstructure can be associated with the variation in the proportion of arsenic.

The author desires to express to Messrs. W. H. Allen, Sons and Co., Limited, his thanks for their permission to publish the results detailed in this paper.

APPENDIX I.

The author feels that some explanation is necessary for the very low figure for arsenic, 0·056 per cent., found in the case of the Rio Tinto copper used in the arsenic series of experiments, because it was this brand of copper for which he gave an average figure of 0·30 per cent. arsenic in his original paper,* to correlate with the results of a large number of experiments on a foundry scale. This figure was the mean of about a dozen results between September, 1913, and September, 1915. It appeared justifiable to conclude that the average figure for arsenic in this particular copper was about the figure quoted. After Mr. Johnson's original paper was published, as he appeared to have come to rather different conclusions as to the effect of arsenic, the author took further steps to verify, if possible, his own previous conclusions, and among other things directed attention to the proportion of arsenic in Rio Tinto copper. It should be noted, however, that the further analysis were being made some three years later than the last analyses quoted, and therefore there is some doubt as to whether the composition of this latter material can in any case be regarded as representative of that previously dealt with. Results were given by the author, obtained from three different ingots drawn at random from each of three different consignments of Rio Tinto copper, delivered September and November, 1918, and which were examined as regards variation in the proportion of arsenic only. Some of these results are decidedly higher than the figure of 0·30 per cent. arsenic that has been previously given as representative of this brand of copper. Now comes the remarkably low result obtained in the particular sample of this copper used in the arsenic experiments. Of the correctness of this figure there is no doubt, because exhaustive attempts have been made to find more, but without success. It is, of course, possible that a change has taken place in the composition of this copper during the intervening period, but there appears even now to be a much greater variation in the arsenic figure in this particular brand than would be expected, and Mr. Johnson was quite justified in his doubts* as to the constancy of composition of a brand, although it will be seen that the data in the possession of the author at the time led to a quite different conclusion. It may be that metal from different sources is marketed under the same brand, as to which the author has no information; but if this is so, it must be rather a disturbing factor in ordinary foundry work, especially when no proper metallurgical organisation is available.

APPENDIX II.

Note on Etching Reagent.—In all cases the acid ferric chloride solution used was of the following composition:

Ferric chloride	10 grammes.
Concentrated hydrochloric acid	20 c.c.
Water	100 c.c.

With arsenical gun-metal, particularly the 1 per cent. alloy, a black deposit is formed on the surface of the specimen. This can be partly removed, with advantage, by rubbing with the finger. It is suggested that, by means of this effect, a rough estimate can even be made of the proportion of arsenic in the alloy, by comparison with the behaviour of samples in which the amount of the impurity is known. This tarnish has been previously noticed by Smalley† in the etching of arsenic brass, and is also referred to by Johnson‡ as occurring with arsenical gun-metal.

* Journal of the Institute of Metals, No. 2, 1918, vol. xx (Plate XV) (facing page 177).

* Journal of the Institute of Metals, No. 2, 1918, vol. xx, page 264.

* Journal of the Institute of Metals, No. 2, 1918, vol. xx, page 274.

† Journal of the Society of Chemical Industry, 1917, vol. xxxvi.

‡ Journal of the Institute of Metals, No. 2, 1918, vol. xx, page 184.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

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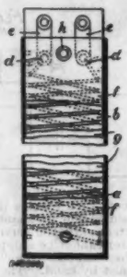
ELECTRICAL APPARATUS

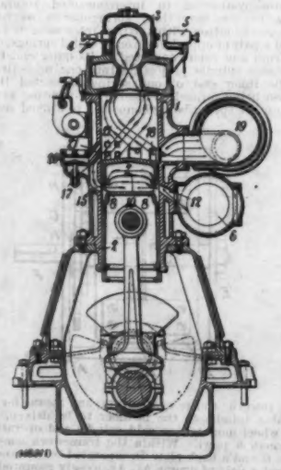
148,009. J. F. Barr, London. Electrical Water-Heating Elements. (2 *Figs.*) May 7, 1919.—The invention relates to heating elements of electrical water heaters of the type comprising a resistance of ribbon form wound around a sheet of mica protected on each side by additional sheets of mica and enclosed in a flattened metal tube. In accordance with the invention, the resistance is wound in the form of a double course thread around serrations on the central mica sheet so that both ends of the resistance terminate at one end of the mica sheet, the ends of the resistance being secured to this sheet by rivets, the current being supplied from the terminals by way of metal strips,



the whole being so arranged that the heating element, including the terminal connections, is of flat form. The heating element consists of a resistance ribbon *a* wound around a flat sheet of mica *b* formed with serrations to receive the resistance, the resistance being wound similarly to a double course thread so that both ends of the resistance terminate at one end of the mica sheet. The ends of the resistance *a* are secured to the sheet *b*, by rivets *d*, current being supplied from the terminals by way of metal strips *c*. On each side of the flat sheet of mica is provided a protecting sheet *f*, *g*, the three sheets being secured together by a rivet *h*. The heating elements so formed is enclosed in a flattened metal tube closed at one end. (*Sealed.*)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

148,011. Frederick Sage and Co., Limited, London, and A. G. Forsyth, London. Pistons. (6 *Figs.*) May 8, 1919.—The invention relates to means for cooling the pistons of internal-combustion engines of the two-stroke cycle type, such as semi-Diesel engines, of a comparatively large size, and more particularly in which a hollow piston head is formed with ports through which air is passed. According to the invention, the super-charge of air passes through the piston. The ports in the hollow piston head are so disposed that when the piston is in its outermost position and cold compressed air is to be supplied for scavenging,



ports in one side of the piston coincide with ports in the cylinder wall communicating with the air supply, and on the other side ports in the piston coincide with ports in the cylinder wall opening into passages in the said wall, the said passage being curved so as to communicate with the air inlet ports in the cylinder wall on the inner side of the piston in its outermost position. 1 indicates the cylinder, 2 the piston, 3 the hot bulb, 4 the fuel valve, and 5 a lamp for heating the hot bulb on starting the engine. 6 is the horizontal cylindrical receiver kept supplied with compressed air by the pump cylinder. The piston 2 has three ports on either side, the central ports extending downwards. Above the ports the piston head is furnished with cross-partitions. In the position shown, the ports on the right of the piston 2 are in register with the ports leading from the compressed air receiver 6, and the ports on the left of the piston 2 are in register with the scavenging ports, so the air is directed into the cylinder at an angle of 45 deg. to its axis, by means of the main scavenging passages 17, and thrusts the exhaust gases out of the cylinder 1, through the four exhaust ports 18 into the exhaust pipe 19. In its passage this cold air passes through the piston head and cools the piston walls and the cross partitions. The piston then rises until its upper edge closes the upper ends of the main scavenging passages 17. The prolonged central ports in the piston 2 are still respectively in register with the air supply port 12 and the scavenging port 15. Air continues therefore to pass through these ports, still cooling the piston, its pressure causing the opening of the automatic valve 20, which then allows it to pass through the supercharge passages 21 into the cylinder, the so-called supercharge of air being thus supplied. The passages 21 are so disposed that they remain open for the necessary time after the exhaust ports 18 are closed. The piston rises during the compression stroke, the fuel is injected through the valve 4, and firing takes place. Scavenging again commences during the down stroke as soon as the exhaust ports 18 are uncovered. The valve 20 being now closed prevents the exhaust gases from passing into the piston and contaminating the air for the next charge during the short period in the down stroke during which the supercharge passages 21 are uncovered before the exhaust ports 18 are uncovered. (*Sealed.*)

148,046. H. R. Ricardo, London. Cylinders. (2 *Figs.*) July 22, 1919.—The invention relates to internal-combustion engines in which both the inlet and exhaust valves are disposed in one and the same side pocket. According to the invention, the cylinder is formed with a flat head which is arranged so as to permit between the cylinder head and the piston only the minimum clearance which is necessary for mechanical reasons. A valve pocket is situated at one side of the cylinder bore, and is formed so as to constitute the combustion space or the major portion thereof, and a port or passage which has substantially the same area as the inlet valve port serves as a communication between this combustion space and the end or bore of the cylinder. That portion of the side pocket which carries the valves is formed integral with the cylinder and the head of the cylinder is preferably detachable. A cylinder A has formed integral with it at one side thereof the inlet and exhaust passages B and C constituting a side pocket in which are the valves B1 and C1. The head D of the cylinder is formed detachable and is machined flat so that at the end of the cylinder A there is provided as at E the least working clearance that is mechanically necessary. In the flat face of the detachable head D is formed a recess D1,

Fig. 1.

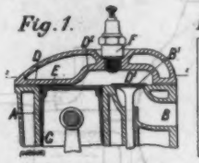
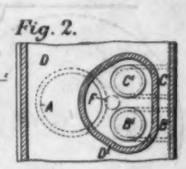


Fig. 2.



which is shaped as shown so that its wall D2 may be said roughly to enclose a triangular space with rounded angles. The greater part of this recess D1 lies over the valves B1 and C1, but a portion of the recess overlaps the end of the cylinder A. The overlapping portion constitutes a port whose area is approximately equal to that of the inlet port controlled by the valve B1. A sparking plug F is mounted about the centre of the recess D1. The detachable head D is provided with a water jacket, and this head may be connected to the cylinder in some convenient manner. Though the construction embodied in this invention involves the formation of a thin layer of more or less stagnant gas which is entrapped in the clearance space E between the cylinder head D and the piston G, since this small clearance is made the minimum which must be provided on purely mechanical grounds, this layer of gas is so chilled that it does not burn completely, and is therefore partially lost from a thermodynamic standpoint, but on the other hand, for the same reason it cannot detonate. The thermodynamic loss in question is negligible in practice, as the volume of gas in the clearance space E is relatively small as compared with that in the remainder of the combustion space. (*Sealed.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

148,066. H. C. Taylor, Hounslow, and W. Divine, Isleworth. Lathes. (5 *Figs.*) September 11, 1919.—The invention relates to centre lathes and consists broadly of a lathe having a slide rest carriage, of which the main saddle extends under the bed and is slidably supported at both sides of the lower portion of the bed. The lathe bed A is constructed in cross-section in the form of a truncated triangle, the top and bottom faces and

Fig. 1.

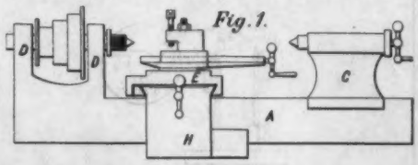
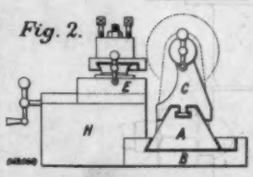


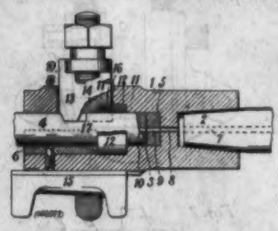
Fig. 2.



the two side faces near the base of the triangle being machined and surfaced to provide for slideable engagement with the tail-stock C, and with the saddle B of the slide rest carriage, which saddle is slidably supported from the under portion of the bed A. It will be seen that the lathe may be so designed that the saddle B, the slide-carrying portion H and its appendent cross-slide E, top slide and tool post may be slid from end to end of the bed A without any interference with the loose poppet C, or the head-stock D. (*Sealed.*)

MINING, METALLURGY, AND METAL WORKING.

146,672. W. E. Nettle, Johannesburg, P. Selby, Johannesburg, J. Blythe, Johannesburg, and J. H. Holman, Johannesburg. Rock Drills. (2 *Figs.*) May 2, 1919.—The invention relates to rock-drilling apparatus in which liquid is passed from a chuck into a hollow tool secured in the chuck. 1 indicates the chuck body which is mounted on or formed integral with the piston rod 2. 3 is the socket in which the tool 4 is inserted. In the bottom of the socket is a hard steel bolster 5, and 6 is a renewable half-bushing for the socket. Water is passed from the bore 7 of the piston rod 2 through a hole 8 in the chuck and a hole in the bolster 5, into the socket 3, whence it passes along the bore 10 of the tool 4. According to this invention, in order to prevent leakage of water between the tool and the chuck body, the socket 3 is counterbored to form an annular recess 11. In said recess is inserted a resilient packing ring 12, the normal internal diameter of which is such that the tool 4 can easily pass through it. The ring fits closely in the recess 11, and provision is made for compressing said ring to cause it to make a tight joint with the walls of its recess 11 and with the surface of the tool 4. For so compressing the ring use is made of the means by which



the tool is secured in the chuck, said means consisting in the present case of the well-known combination of a pad 13, U-bolt 14 and wedge 15. The recess 11 is positioned to intersect the opening 16 through which the pad 13 enters the chuck body, and the pad is recessed at 11a to complete the recess 11. Upon the pad being tightened down by means of the wedge 15 its lower concave surface 17 grips upon the tool to hold the same, and at the same time its recessed part 11a compresses the packing ring 12. The packing ring is thereby displaced and forced into close contact both with the tool 4 and with the enclosing surfaces of its recess 11, thus effectually preventing the passing of fluid from the rear end of the socket 3, except through the bore of the tool. Upon the pad being loosened to release the tool the constriction of the packing ring on the tool is removed and the tool may be easily withdrawn without abrading the ring. The front end of the pad is formed with a swelling 19 which enters a correspondingly shaped opening 18 in the front wall of the pad opening 16, whilst the back end of the pad is flat. This obviates insertion of the pad wrong way about and consequently cutting of the packing ring 12. (*Sealed.*)

MOTOR ROAD VEHICLES.

146,714. A. Ryner, London, and W. B. Wilson, Eltham. Springs. (4 *Figs.*) March 17, 1919.—The invention relates to springs for road vehicles. Each spring consists of two springs *a*, *a*, composed each of a plurality of plates, the shortest plates in both springs being uppermost. The said upper and lower springs are rigidly coupled together, but vertically separated from each other by a distance-piece at each end, that at the front end *b* being provided with a shank *c* which carries an eye *d*, by means of which the spring device is pivotally attached to the underframe or other convenient member of the vehicle, whilst the distance-piece *e* at the rear end is bored at *f* to contain the rear axle tube of the vehicle. The said upper and lower plate springs are bolted together at or near their longitudinal centres

by a casting or distance-piece *g*, which is prepared to receive a device capable of carrying the extremity of a fixed member of the vehicle, and capable of permitting torsional as well as vertical movement in such coupled spring. The distance-piece *g* may be prepared for the reception of a cross-head which is furnished with trunnions journalled within the distance-piece casting *g* in the long axis of the device, such casting being in two halves, the ends of such trunnions terminating in a suitable keep nut. The recesses in which such nuts are housed may be closed by a dust cap. The crosshead is journalled upon the extremity of a fixed member of the vehicle and is capable of partial rotary movement thereon. The said fixed member is retained in its position within the crosshead by means of a keep nut protected from dust by a dust cap. (*Sealed.*)

147,397. T. Sloper, Devizes. Wheels for Vehicles. (5 *Figs.*) April 17, 1919.—The invention relates to wheels for vehicles. According to the invention, a rim or band is provided with a winding of wire secured on it in one or more layers round its outer face. The band A is a channelled band having circum-

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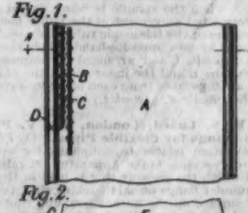


Fig. 2.

ferential flanges at both edges. Around the outer face of the band a wire B is helically wound with its laps slightly spaced apart. The wire B is served with or has wound on it another wire C of smaller gauge and the latter raises the wire B above the outer surface of the band A. This form is particularly suitable when the outer surface of the band is smooth, that is to

say, is formed without projections upon which to raise the wire. The two ends of the wire B may be secured as shown at D to the flanges of the band A. In building up such a band tyre the compound wire B, C, is applied round the outer face of the band A and the rubber portion E is thereafter built up on to the band, thus wrapped with wire. The rubber is forced in between the laps of the wire and is finally vulcanised in position, the vulcanisation being carried out in the usual manner. (*Sealed.*)

PUMPS.

147,283. G. Handley, London, and P. W. Bullock, London. Rotary Pump. (5 *Figs.*) April 16, 1919.—The pump is of the rotary pendulum type, and the novel feature consists in the method of mounting the pump as a twin pump when it is desired that a slow-speed pressure pump shall be driven from a high-speed shaft, for example, a dynamo shaft or the camshaft of an internal-combustion engine. The invention is particularly applicable in the case of a boiler-feed pump where a slow, steady supply under pressure is required, or for forced

Fig. 1.

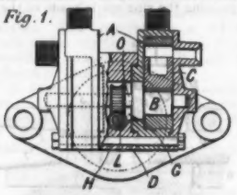
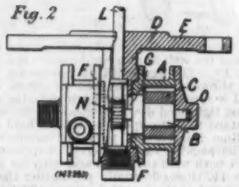


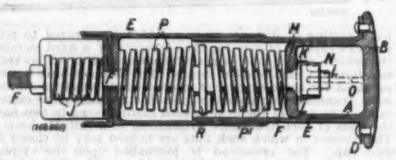
Fig. 2



lubrication. A, A are the casings of the twin pumps, B the eccentrics and C the pendulum-rotors thereof. D is a bracket having a plate E whereby it may be secured to the frame of any piece of machinery or object. The pump casings A, A are provided with cylindrical projections F, adapted to fit into the correspondingly-shaped ends of a chamber G in the bracket D, the casings being held in position by bolts H. In bearings in the bracket D there turns a shaft L having fitted thereon a worm engaging a worm wheel N on the common driving shaft O of the two pumps. (*Sealed.*)

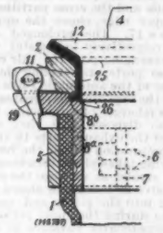
RAILWAYS AND TRAMWAYS.

148,065. S. T. Gresham, London. Buffers. (4 *Figs.*) September 11, 1919.—The invention relates to buffers of the kind in which the buffer spring is guided on a spindle passing through a cradle within the telescopic tube of the buffer, the cradle and buffer proper being retained by a collar on the end of the spindle. According to the invention, the cradle, in which the head of the spindle loosely fits, instead of being secured to the telescope as hitherto, is carried directly upon the buffer face or head, and thus the connection is not subjected to shear. A cradle A is shown formed integrally with a buffer face B secured to a flange D on the outer end of a telescopic tube E. A spring-guiding spindle F is located in the tube E and extends at its inner end through apertures in the base of the tube and the wall of the vehicle, where it is secured by a nut and spring J. The inner end of the tube E is itself secured to the wall. The outer end of the spindle F is provided with an enlarged



spherical head K which forms a usual ball-and-socket joint with a counterpart seating in the base of the cradle A. A lateral opening L is formed in the cradle to allow the spindle with its enlarged head to be passed into the central aperture M in which the spindle end bears. To prevent rotation of the spindle F while the nut is being adjusted, the former is provided at its outer end with an extension M which is adapted to engage a radial rib O within the cradle A. Although rotation of the spindle is in this way prevented, its lateral movement is not interfered with. The opening L is so dimensioned as to clear the extension N when the spindle is being passed into position. To minimise rotational movement of the buffer face B relatively to the fixed portion of the telescopic tube, the usual single buffer spring is replaced by two opposite-handed helical springs P, P1, mounted on the spindle F and arranged in compression between the base of the tube E and the inner end of the cradle A. The springs P, P1, are separated from each other by a collar R loosely mounted on the spindle F. (*Sealed.*)

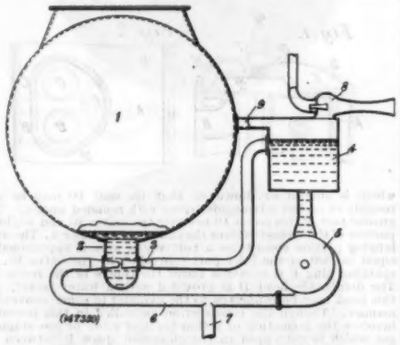
146,797. E. S. Luard, London, and V. P. Rawlings, London. Couplings for Flexible Pipes. (1 *Fig.*) July 15, 1919.—The invention relates to couplings for connecting the flexible pipes of vacuum brake apparatus on railway vehicles, of the kind in which the packing ring is held in the coupling by clamping an annular flange on said packing ring, between a rearwardly facing surface on the horned coupling ring or collar and a forwardly-facing surface on the tubular member to which the flexible pipe is clamped. 1 is the end portion of the flexible pipe and 2 the solid collar carrying the usual coupling horns 4. 5 is the usual clip or clamping ring which embraces the pipe end, 6 being the clamping bolt passing through the usual or any suitable lugs 7 on said clamping ring. 8a is an internal tubular member or sleeve. The packing ring consists of a tubular body portion 11 with a joint-making flared portion 12 at one end and an outwardly-projecting annular securing flange at the other end. The joint-making flange 12 lies against a sloping face on the collar 2, and the flange takes behind the collar 2, and is held there-against by the tubular member 8a. 25 is a cylindrical metal sleeve which fits snugly in the bore of the tubular packing ring 11 to back up said ring and render its unauthorised removal more difficult, said liner 25 having an out-turned flange 26 adapted to take between the annular rear face of the packing ring 11 and the opposing face of the recess 8b in the tubular member 8a. It will be seen that the liner 25 extends forwardly or outwardly of the coupling to the point where the joint-making portion 12 begins to flare or splay outwardly. For securing the



collar 2, with the packing ring, to the tubular member 8a when the parts are assembled, the catch members 19 are turned to the position shown, and their heads are sprung into the above-mentioned depressions, the resilience or spring action of the flange of the packing ring firmly holding the catch members in the position shown. The pipe clip 5 is next placed in position and locks the catches 19 with their heads in engagement with the depressions. (*Sealed.*)

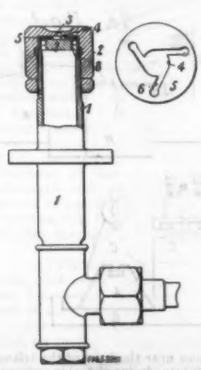
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

147,350. A. E. L. Scanes, Ashton-on-Mersey, and Metropolitan Vickers Electrical Company, Limited, Westminster. Steam-Condensing Apparatus. (*Fig.* 1.) July 16, 1919.—The invention relates to apparatus for removing condensed steam from surface condensers working under vacuum, of the type wherein the condensate is withdrawn from the condenser by means of a hydraulic ejector and discharged into a tank or the like, from whence it is removed by means of a hot well or boiler feed pump. According to the invention, the pressure in the tank or hot well into which the condensate is discharged is maintained lower than the pressure existing in the condenser.



1 indicates a steam condenser, the condensate from which collects in the well 2, and is withdrawn therefrom by means of a hydraulic ejector 3, which discharges it into a closed tank 4. Water from the tank 4 is extracted by means of a pump 5, a portion being supplied through the pipe 6 to operate the ejector 3, and the remainder being discharged to a feed water heater or direct to the boiler through the pipe 7. The pressure in the tank 4 is maintained lower than that existing in the condenser 1 by means of an air extracting device 8 illustrated as being a steam ejector. The air outlet 9 from the condenser is connected directly to the tank. The water in the tank 4 is maintained at the proper level. An auxiliary supply of make-up water to the tank is provided. (*Sealed.*)

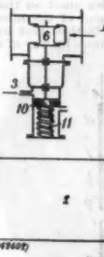
145,320. Babcock and Wilcox, Limited, London, and A. Spyer, London. Liquid-Fuel Spraying Device. (6 *Figs.*) October 7, 1919.—The invention relates to liquid-fuel spraying devices for atomising and injecting oil in the form of spray into the combustion chamber of a furnace. The novel feature consists in interposing between the open end of the barrel and the distri



bution plate a removable diaphragm formed near its periphery with an annular recess and having a number of perforations for passage of fuel through the diaphragm to the recess, whence the fuel is free to flow along the tangential slots to the central chamber in the distribution plate, from which latter it emerges through the central orifice of the cap. 1 denotes the barrel to which is fitted a cap 2 having a central orifice 3. In register with the orifice 3 is a central chamber 4 in a distribution plate 5, having tangential slots 6 extending from the central chamber 4 towards the periphery of the plate. 7 denotes a diaphragm interposed between the slotted plate 5 and the interior of the barrel 1, the diaphragm 7 being formed with an annular recess 8 and with perforations communicating with the recess 8. The slotted plate 5 and the diaphragm 7 are readily removable so that a plate or a diaphragm of one form may be readily substituted for a plate or a diaphragm of another form. (*Accepted July 7, 1920*).

147,402. Maschinenfabrik Oerlikon, Oerlikon, Switzerland. Steam-Driven Vehicles. (4 *Figs.*) December 31, 1919.—The invention relates to a turbo-generator installation for locomotives. The installation consists of a main group and an auxiliary group. The main group furnishes current to the driving motors of the vehicle, whereas the auxiliary group generates the exciting current for the main group as well as the current for the auxiliary machines, such as ventilators and pumps. The main group consists of a steam turbine 1, and a polyphase generator 2, which supplies current to the driving motors of a vehicle. The auxiliary group consists of a steam turbine 3 and a direct-current generator 4, which supplies current for exciting the polyphase generator 2 as well as to several auxiliary motors which are not shown in the drawings. The steam is admitted to both turbines through the common main 5. The steam can be shut off by means of valves 6 and 7. The speed of the main group 1, 2, is variable with the speed of the vehicle. The main group cannot be put under load unless the auxiliary group 3, 4, supplies the exciting current; the exciting current, however, must not be arbitrarily switched off or on, since otherwise it might happen that the periodicity of the driving motors would not coincide with that of the main group, thus causing breakdown

Fig. 2.



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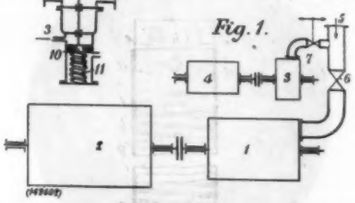
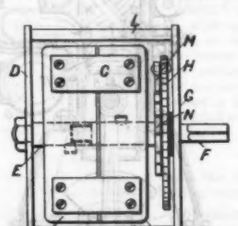


and damage. To prevent such trouble the inlet valves 6 and 7 in the plant under consideration are so interlocked that the main group cannot be started until the auxiliary group is already running; and this latter cannot be stopped until after the main group is stopped. To start the vehicle, the valve 7 of the auxiliary group is opened by hand. The inlet valve 6 is opened by oil pressure transmitted through a pipe to the upper side of the piston 10, whereby the valve 6 is opened against the pressure of a spring 11. Both main and auxiliary groups are provided with their own oil pumps, the pipes of same being connected together. The devices allow the main turbine to be started only when oil pressure is available, i.e., when the auxiliary turbine is running. In this way, the proper sequence of the starting operations is ensured. To obviate breakdown and damage to the machinery, provision is also made for preventing the auxiliary turbine from being stopped until the inlet valve 6 to the main turbine has been closed. With this object a three-way cock, which admits the oil to the piston 10, is set in such a manner that when the pipe is open, the hand wheel of the valve 7 cannot be brought into the closing position. Consequently, as is requisite, the main turbine has to be stopped before the valve 7 of the auxiliary turbine can be closed. (*Sealed.*)

MISCELLANEOUS.

147,339. T. F. Redington, Thornton Heath, and H. B. Collins, Westminster. Spring-Driven Mechanism. (3 *Figs.*) December 16, 1919.—The invention relates to spring-driven mechanism of the kind wherein a pair of springs is arranged with one end of one spring fixed, and the corresponding end of the other spring operatively connected to the winding means, and to the member to be driven, and the opposite ends of the springs are connected to interconnected rotatable drums. According to the invention, spring-driven mechanism comprises the combination with a pair of interconnected and coaxial drums and a pair of oppositely-wound coiled springs, one disposed in each drum and each connected at its outer end to its drum, of a rotatable spindle projecting into one or both drums and having the inner end of one spring connected thereto, said spindle also being formed to receive the winding key, the inner end of the other spring being connected to a fixed spindle or pin



projecting into the centre of its drum, and means for connecting the rotatable spindle to the member to be driven, comprising a ratchet wheel mounted on said spindle and operating a tooth wheel through a pawl. Within the framework consisting of a front plate G and a back plate D, separated by distance pieces L, are arranged a pair of drums A1, A2, loosely mounted on a fixed stud E projecting inwards from the back plate D, and a rotatable spindle F mounted in the front plate G. The stud E is drilled at its end to form a bearing for the spindle F. The drums A1, A2, are connected together by driving plates C, and on the spindle F is mounted a ratchet wheel N which operates through a pawl M, a gear wheel H. Within the drum A1 is a coiled spring connected at its outer end to the drum and at its inner end to the spindle F; an oppositely-wound spring is arranged within the drum A2 and has its outer end connected to the drum A2 and its inner end to the fixed stud E. The spindle F also constitutes a winding pin. (*Sealed.*)